Subscription Price, $4.00 per Annum; to Members $1.00.

Entered at the Philadelphia Post-Office as second-class matter.

PUBLISHED QUARTERLY.

PROCEEDINGS

OF THE

AMERICAN PHILOSOPHICAL SOCIETY,

HELD AT PHILADELPHIA, FOR PROMOTING USEFUL KNOWLEDGE.

VOL. XXII. APRIL, 1885. PART II. No. 118.

TABLE OF CONTENTS.

PAGE.

On the Language and Ethnologic Position of the Xinca Indians of Guatemala. By *Daniel G. Brinton*..... 89

Stated Meeting, January 2, 1885..... 98

Stated Meeting, January 16, 1885..... 101

The limits of stability of nebulous Planets, and the consequences resulting from their mutual relations. By *Daniel Kirkwood*..... 104

Notes on the Geological Structure of Tazewell, Russell, Wise, Smyth and Washington Counties of Virginia. By *John J. Stevenson (with map)*..... 114

Some Notes Respecting Metamorphism. By *John J. Stevenson*..... 161

Twelfth Contribution to the Herpetology of Tropical America. By *E. D. Cope*..... 167

The Lineal Measures of the Semi-Civilized Nations of Mexico and Central America. By *Daniel G. Brinton*..... 194

An Experiment in Weather Forecast. By *Pliny Earle Chase*..... 207

Note on Cosalite, Alaskaite and Beegerite. By *George A. Koenig*. 211

The Remarkable Sun-glows in the Falls of 1883 and 1884. By *Wm. Blasius*..... 213

A convenient Device to be applied to the Hand Compass. By *Persifor Frazer*..... 216

PUBLISHED FOR THE AMERICAN PHILOSOPHICAL SOCIETY,

BY

McCALLA & STAVELY,

NOS. 237-9 DOCK STREET PHILADELPHIA.

EXTRACT FROM THE BY-LAWS.

CHAPTER XII.

OF THE MAGELLANIC FUND.

SECTION 1. John Hyacinth de Magellan, in London, having in the year 1786 offered to the Society, as a donation, the sum of two hundred guineas, to be by them vested in a secure and permanent fund, to the end that the interest arising therefrom should be annually disposed of in premiums, to be adjudged by them to the author of the best discovery, or most useful invention, relating to Navigation, Astronomy, or Natural Philosophy (mere natural history only excepted); and the Society having accepted of the above donation, they hereby publish the conditions, prescribed by the donor and agreed to by the Society, upon which the said annual premiums will be awarded.

CONDITIONS OF THE MAGELLANIC PREMIUM.

1. The candidate shall send his discovery, invention or improvement, addressed to the President, or one of the Vice-Presidents of the Society, free of postage or other charges; and shall distinguish his performance by some motto, device, or other signature, at his pleasure. Together with his discovery, invention, or improvement, he shall also send a sealed letter containing the same motto, device, or signature, and subscribed with the real name and place of residence of the author.

2. Persons of any nation, sect or denomination whatever, shall be admitted as candidates for this premium.

3. No discovery, invention or improvement shall be entitled to this premium, which hath been already published, or for which the author hath been publicly rewarded elsewhere.

4. The candidate shall communicate his discovery, invention or improvement, either in the English, French, German, or Latin language.

5. All such communications shall be publicly read or exhibited to the Society at some stated meeting, not less than one month previous to the day of adjudication, and shall at all times be open to the inspection of such members as shall desire it. But no member shall carry home with

PROCEEDINGS

OF THE

AMERICAN PHILOSOPHICAL SOCIETY,

HELD AT PHILADELPHIA, FOR PROMOTING USEFUL KNOWLEDGE.

VOL. XXII. MARCH, 1885. No. 118.

On the Language and Ethnologic Position of the Xinca Indians of Guatemala. By Dr. Daniel G. Brinton.

(*Read before the American Philosophical Society, October 17, 1884.*)

In the aboriginal ethnology of Guatemala, the affiliations of the Xinca tribe have always remained uncertain. The opinion is expressed by Dr. Stoll (*Zur Ethnographie der Republik Guatemala*, p. 170, Zürich, 1884) that an investigation of their language might throw a new light on the migrations of the ancient inhabitants of that region.

Up to the present time, however, no words of their language have been published, and students have had no means of comparing it with the dialects which surrounded them. I am fortunate enough to be able to supply this deficiency to a moderate extent, and to offer sufficient materials to form some opinion as to this people.

Their precise location was on the Rio de los Esclavos and its branches, which empties into the Pacific ocean, about N. lat. 13° 50′, W. long. 90° 25′, and westward to the Rio Michatoyat. Their area embraced most of the departments of Santa Rosa and Jutiapa, and may roughly be said to have extended about fifty miles along the coast, and back to the Sierra some sixty miles.

On the west they were bordered by the Pipiles, of Aztec lineage, speaking a Nahuatl dialect not much corrupted; on their north were the Pokomams, who belonged to the Maya stock, and on their east was a colony of Popolucas, a tribe supposed to have been related to the Mixes of the Isthmus of Tehuantepec.

Their name has been variously spelled, Xinca, Xinka and Sinca. The first given is correct, the initial X having the value of the soft English *sh*, as in *show*.

According to the *Geografia de las Lenguas Maya-Kiche*, MS. of Dr.

Berendt, the Xinca is or was spoken in the following towns or villages in the district mentioned :

Atescatempa,	Mustiquipaque,
Atiquipaque,	Nancinta,
Chiquimulilla,	Sinacantan,
Comapa,	Tacuilula,
Guazacapam,	Taxisco,
Ixguatan,	Tepeaco,
Jupiltepeque,	Tescuaco,
Jutiapa,	Tupitepeque.

The first information about the Xincas is contained in the letter of Pedro de Alvarado to Hernan Cortes, dated July 28, 1524.* He there describes his conquest of their territory in the previous winter. Further particulars of the campaign are given by Juarros, in his *Historia de Guatemala*, Tom. ii, Tratado iv, Cap. xxii, from the MSS. of Fuentes.

From these sources we learn that Alvarado first encountered the Xincas after he had crossed the River Michatoyat and entered the town Atiquipaque (*Atiepar*, in Alvarado's letter, who makes as much havoc with the native names as he did with their armies).

In this town he particularly states that he met another people and a different language from those he had just left ("este es otra lengua y gente por si").

Thence he proceeded to Tacuilula and Taxisco, not encountering determined opposition, as Juarros erroneously says, as Alvarado informs us that the natives received him without fighting, but fled in the night to the forests. After leaving Taxisco, however, they attacked him in force and slew many of his allies.

The chief town of the Xinca would seem to have been either Nancinta (the "*Nacendelan*, pueblo muy grande" of Alvarado's letter) or according to Juarros, Guazacapam. In this vicinity a determined stand was made by the Indians, and they caused the Spaniards and their allies much trouble by digging pitfalls, and by planting the paths with sharpened sticks said to be poisonous. What puzzled the Spaniards was that these natives during their fighting held in their hands small bells with which they made as much noise as possible. Probably they were intended either as charms, or to alarm the enemy.

Juarros adds that these tribes were not conquered by Alvarado's incursion. It required renewed efforts by Don Pedro Portocarrero, in 1526, to bring them under subjection.

On account of their obstinacy, numbers of them were sold as slaves and branded with a hot iron, and hence was derived the Spanish name of the river on which the Xincas lived, *Rio de los Esclavos*, Slave river.

Very few hints as to their social condition are found in the early

* I quote it as published in the *Biblioteca de autores Españoles*, Vol. xxii, Madrid, 1852.

accounts. Their country is stated to have been populous, their towns built of wood and not of stone, they were skillful with the bow and arrow, and were bold warriors. They formed small independent tribes united in a sort of confederacy, the "cabeza de señorio," or chief clan, being at "the famous town of Guazacapam," and its four dependents or allies are named as,

Nestiquipaque,	Guaimango, and
Chiquimulilla,	Guanagazapa.

The linguistic materials I offer are vocabularies of three dialects of the Xinca.

The first, from Sinacantan, was obtained from a native of that place by the distinguished historian and antiquary, Don Juan Gavarrete, of Guatemala, in 1868. The other two were obtained for him in the same year by Don Sebastian Valdez, Cura of Jutiapa. As according to Dr. Stoll, the originals of these have disappeared, no one knows where, since Señor Gavarrete's death, the present publication seems the more appropriate, presenting as it does the only specimens of the Xinca language known to be in existence. I would not omit to add that they came into my hands, together with other valuable documents, in the collection of the late Dr. C. Hermann Berendt.

Phonology of the Xinca.

The language is vocalic, and with few gutturals or harsh palatals, contrasting in this respect with the Cakchiquel and other Maya dialects. The labials, *b*, *f*, and *v*, are absent, although *b* is found in two or three words of the accompanying vocabulary. The linguals are not prominent, the *d* and *th* not appearing at all. The semi-vowels *r* and *l* are convertible in the dialects and occasionally alternate with *n*.

In the vocabularies, the letters have the powers of the Spanish alphabet, except that *x* is pronounced like *sh* in *she*, the *v* is the neutral vowel as in *but*, the *z* is the same as the *s*, and the compounds *csh* and *sch* appear to have the value of the *x* (= sh).

Vocabulary of the Xinca Language.

LOCALITY.	*Sinacantan.*	*Jupiltepeque.*	*Jutiapa.*
Man,	jurac,	jumu,	jurgaqui.
Woman,	ayala,	aya,	aiya.
Boy,	xurum,	sorone,	soroni.
Father,	tatan,	tataj,	tataj.
Mother,	utan,	utaj,	utac.
Son,	najuum,	nauij,	naguij.
Daughter,	jaya najuun,	—— ——	naguij
Brother,	xuyam,	keruke,	suyac.
Head,	jamatan,	usajle,	gesalia.
Hair,	mux jumatan,	mosal,	musal.
Eyes,	jurtin,	juratii,	yuratica,

Locality.	*Sinacantan.*	*Jupiltepeque.*	*Jutiapa.*
Nose,	jutu narin,	—— ——	narica.
Nostril.	uona narin,	—— ——	lurate.
Ear,	maman,	mami,	manca.
Mouth,	xa'jan,	xajac,	sajac.
Tongue,	ejlan,	ela,	eglajac.
Teeth,	jari xa'jan,	—— ——	sajac.
Throat,	ta'tam,	—— ——	tarti.
Breast,	ziquim,	tutu,	—— ——
Arm,	pum,	paja,	paja'.
Hand,	jixi pum,	pu,	puj.
Fingers,	mux,	pere pu,	pere puj.
Belly,	jiguin,	ururi,	ururi.
Leg,	titan,	kegüe,	uapi.
Knee,	jaricomon,	sulna,	—— ——
Foot,	uapan,	uapi,	guapi.
Town,	machiname,	saguqui,	saguqui.
House,	macu,	—— ——	macu.
Bed,	a'tac,	alutu,	alutaj.
Hamack,	guaro,	—— ——	guaro.
Mortar (mill stone),	uiki,	uík,	uic.
Plate,	aulac	aljuat,	augeal.
Jar,	erec,	—— ——	erec.
Fire,	uray,	uu'ra,	icura'.
Water,	ui,	—— ——	huy.
Maize,	aima,	—— ——	ahua.
Ear of maize,	—— ——	—— ——	aima.
Bean,	xinac,	sicna,	cshidna.
Salt,	tita,	—— ——	tila.
Hat,	ta'yuc,	—— ——	tayuc.
Breeches,	xu'nan,	asuna,	asiuna.
Paper,	papooc,	papu,	popoque.
Heaven (sky),	uina,	—— ——	güigna.
Sun,	pari,	parri,	parri.
Moon,	agua,	—— ——	ahua.
Star,	xune,	hueso,	güeso.
Day,	pari,	ti parri,	ti parri.
Night,	chamazoma,	chijmac,	schugmac.
Wind,	tan,	una,	yeuha.
River,	xanjui,	tire,	ture.
Hill,	naguona,	kerter,	querter.
Woods,	jaragua,	casagua,	caragua.
Road,	tasma,	talma,	talma.
Cornfield,	uaya'a,	uayaaj,	guaya'.
Earth (land),	naro,	narro,	narro.
Stone,	jixi,	ixe,	gicshe.

Locality.	*Sinacantan.*	*Jupiltepeque.*	*Jutiapa.*
Tree,	jutube,	utis,	utu′.
Ceiba,	pa′guac,	— —	— —
Banana,	jugua,	— —	— —
Jaguar,	uijlay,	uilay,	guilai.
Deer,	tuma,	— —	tubma.
Jabali,	cargua jaxo,	— —	— —
Dog,	pelo,	— —	— —
Snake,	jurumuy,	urunugui,	urunugûi.
Fish,	seema,	samu,	giamuc.
God,	tiuix,	— —	— —
Soul,	terouala,	namasamac,	— —
Alive,	ixiuac,	ixij,	isig.
Dead,	teroa′ar,	tero′,	tero′.
Old,	merc,	mochi,	mochi.
White,	mooti′,	moatij,	mougua.
Black,	zumati,	simatij,	sijmatig.
Red,	tenati,	tenajtij,	tenajtig.
Yellow,	meelati′,	totojtij,	— —
Green,	mee,	meyatij,	meyatij.
Blue,	mee,	— —	— —
Bright,	minabar,	— —	— —
Dark,	zama,	— —	— —
Above,	xam,	— —	— —
Below,	xama′,	— —	— —
Yes,	jaa,	— —	— —
No,	xim,	— —	— —
Good-day,	— —	— —	cshi mani maqui con Dios.
Good-night,	— —	— —	cshi manusiguai con adios.
Good-bye,	— —	— —	coo-par.

Numerals.

1.	ica,	ical,	ical.
2.	ti,	piar,	pia′r.
3.	uala,	ualar,	guarar.
4.	jiria,	iriar,	iriar.
5.	pɐj,	pijar,	pujar.
6.	tacal,	—	tacalar.
7.	pujua′,	puljar,	pulluar.
8.	tapɐc,	apuj,	apocar.
9.	uxtu′,	—	gerjsar.
10.	pakil,	—	paquilar.

Comments on the Vocabulary.

Man. *Jumu.* In the Xicaque language of Honduras *jome* = man, but as this is the only close similarity in a comparison of thirty seven words, I attribute it to accident; *jurac* has a faint resemblance to Cakchiquel *hun uinak*, one man.

Father. *tataj*, is evidently the universal baby word for father, and its analogies are worthless for tracing affinities. The same is true of *utaj*, mother. Compare Germ. *Vater, Mutter*, Cakchiquel *iata.*

Son. *najuum*, in Pokomchi *akun*, probably an accidental resemblance.

Daughter. *jaya najuun, jaya* evidently from *aya*, woman, female, hence "female child," the combination showing that *najuun* does not mean son, but child, offspring.

Brother. *xuyam* and *keruke* are evidently wholly different words, and are either used by the different sexes, or apply the one to an elder the other to a younger brother.

Hair. *mux jumatan* (the last word no doubt an error for *jamatan*, literally "the fingers of the head" or more properly "the extremities, the small branches of the head"). See Fingers. *musal* is apparently a synthesis of *mux*, and *gesalia*, with the same signification. Such compounds indicate that the Xinca is more synthetic than the Maya dialects.

Nose. *narin, narica*, may be the Spanish *nariz*, nose.

Teeth. The words *xa'jan* and *sajac*, mean mouth. The prefix *jari* seems to mean either bone, or front part, as it re-occurs in *jaricomon*, knee (knee-cap ?).

Breast. *tutu* may be Spanish *teta*, but in the Maya dialects we find Cakchiquel and Quiche *tu*, tit, mamma. Pocoman, *tuj*, Chol., *txu; ziquim* may be related to Quiche *tz'um*, mamma.

Hand. *jixi pum*, probably "the end of the arm." In none of the Maya dialects is there any separate word for "hand." The hand and arm are included in one term, the proper translation of which is "the upper extremity." When it is desired to distinguish between hand and arm, a compound must be formed, or the distinction be left to the hearer. *Jixi* is also given for stone; perhaps the stone point or end of the arrow explains the identity of the expressions.

Fingers. On *mux*, see teeth. *pere pu*, from *pum*, upper extremity, and a prefix probably signifying ends, tips, or branches.

Leg. *uapi*, means foot, q. v.

Knee. See teeth. The two words given evidently mean different things.

Foot. *uapan.* Comp. Cakchiquel *akan.*

Town. *machiname.* This is plainly the Pipil *chinamitl*, town, with a prefix *ma.*

Mortar. Span. *piedra de moler*, the hollowed stone on which the women pound the corn.

Plate, in the original, *comal*, from Nahuatl *comalli*, a shallow earthen dish used to prepare tortillas.

Maize. The word *aima* given for maize and ear of maize is found in precisely the same form in Chontal, and in Lenca *ama*. I am inclined to derive it from *ixim* (pronounce *ishim*) the universal word for maize in the Maya family. Later, we have for corn field *uaya'a*, which is close to the Cakchiquel *auan*, cornfield, or *auex*, when the corn is young. If this is correct, it would indicate that the neighboring tribes learned the cultivation of corn from the Maya stock, which is the more significant as it is now the opinion of botanists that the native habitat of the *Zea mais* was in Guatemala where it was developed artificially from the wild *Euchlæna luxurians*. The other word given for maize, *ahua*, is identical with that for "moon." This may possibly refer to an identification of the moon as the goddess of maize. In Chipeway the name of maize is *mandamin*, "the grain, *min*, of the god, *manito*."

Beans. *xiñ'ac* is the Cakchiquel, *tzinak*, Tzendal *txenek*. Evidently the Xincas got their corn and beans first from their neighbors of Maya lineage.

Salt. *tita*, from Nahuatl *iztatl*. This article the Xincas learned from their Nahuatl speaking neighbors, the Pipiles.

Breeches. All three words are corruptions of the Spanish *calzones*.

Paper. The words are corruptions of Span. *papel*.

Heaven or Sky. *uina'*, closely allied to Zotzil *uinaje'l*.

Sun and Moon. In pure Maya the general root for sun is *ki*, for moon, *u*. But in the Kekchi, Pokomchi and Pokomam we have for moon the totally different word *po*. This seems to be the radical of *parri*, sun, in Xinca. Further, in Chañabal and Mam we have for moon *ixa'u*, where the *ix* is probably the feminine prefix, leaving for moon *a'u*, a kin to Xinca *ahua*.

The word *ahua* bears a superficial resemblance to *huy*, water, but a close examination of these tongues does not bear out Dr. Trumbull's theory, of a radical connection between the expressions for sun and water. (See *Proceedings of the American Philological Association*, 1875–6, p. 45.)

Star. *xune*, allied to Cakchiquel, *tzumil*, star; *hueso* appears to have no connection with Maya dialects.

Day. *pari*, the same as sun.

Night. *chijm—ac*, Cakchiquel *aka*, night, perhaps with the preposition *chi*, at, "by night," "at night."

Wind. *yeuha*, Pokonchi *te'ug*.

Tree. *utis*, Tznedal *te*, Chol *tie'*.

Jaguar. *uilay*, Pokomchi, *baijlam*.

Deer. *tuma*, Chontal, *chima'*.

Jabali. *cargua*, from *caragua*, woods, *jaxo*, Pokomchi, *aj'k*, hog, wild hog; compare the name of the same animal in Pokomchi, *quichę ajk*, wood-hog.

Dog. *pelo*, Spanish, *perro*.

Soul. *terouala*, in which *tero* is the adjective "dead."

Alive. *ixij*, Aguacateca, *itzin*, Tzendal, *c'uxul*.

Old. *mochi*, Maya, *noixib*, Tzotzil *mo'ol*.

Colors. The names of all the colors differ totally from the Maya. They appear to have a generic suffix, *ati*, appended to the radicals

mo, white.	*teu*, red.
sim, black.	*tot*, yellow.

me, blue or green.

The word *meelati* for yellow is probably a mistake, and the identification of blue and green is common in the radicals of most Central American tongues as I have elsewhere pointed out (*The Names of the Gods in the Kiche Myths, Proc. Am. Phil. Soc.*, 1881).

For comparison I add the Maya radicals for colors, as presented in the Kiche dialect.

zak, white.	*cak*, red.
gek, black.	*gan*, yellow.

rax, blue or green.

It is evident that there is not the slightest relationship, and they are equally remote from the Pipil and Aztec color names.

Numerals. The numerals indicate few and faint similarities to any of the other Central American or Southern Mexican languages with which I have compared them; *ica*, one, is like Mangue *tica*, and the four first may be compared with the Lenca of Honduras as follows:

Xinca.	Lenca
1. ica,	ita.
2. piar,	pe.
3. uala,	lagua.
4. jiria,	aria.

But I regard this as accidental, as it is not borne out by the remainder of the Lenca vocabulary, in four dialects, which I have brought into comparison.

The termination *ar* in the Jalapa dialect reminds one of the suffix *uual*, indicating turn or repetition, found in the Ixil numerals, a rather pure Maya dialect, thus:

ungvual,	one time.
cavual,	two times,
ox ual,	three times, etc.

God. *tiuix*. Gavarrete appends the note to this word: "It does not properly signify God, but image or idol. At present it is applied to the images of the saints." It is probably from the Cakchiquel *tioh*, great, divine, a word employed in a religious sense. This indicates the origin of their ancient cult.

The number five, *puj-ar*, is clearly the noun *puj*, hand, and refers to the five fingers.

Six, *tacal*, appears to be a compound of *ti-ical*, — second, first, *i. e.*, the first finger of the second hand. In seven, *puj-ua*, and eighth, *a-puj*, the word *puj*, hand, is apparently present.

From this analysis I reach the conclusion that the Xincas belonged to a different linguistic stock from the Mayas or the Pipiles (Nahuas). They were a rude tribe, who first learned the planting of corn and beans from the Cakchiquels or Pocomams, some parts of their religious rites from the same, the use of salt, and some of their village organization from the Pipiles, and portions of their present dress from the Spaniards.

They spoke a vocalic language of monosyllabic radicals, whose themes are chiefly formed by suffixes.

It may be that they were the rude primitive folk who once extended over Guatemala and were forced down to the coast and into the restricted limits were they were first found, by the warlike immigration of the Maya and Nahua races, both of whom distinctly remembered a foreign origin.

We know little of the date of the advent of the Cakchiquels and Pocomams into Guatemala. But a traditional history of it is preserved in the "Annals of the Cakchiquels," written shortly after the Conquest by Francisco Ernantez Arana Xahila, the original MS. of which is in my possession. He informs us that when his ancestors entered Guatemala large tracts of it were uninhabited, and other portions were peopled by a race who, even to the Cakchiquels, appeared as barbarous, and so rude that they called them *chicop*, brutes. They had captured two of these, and learned some words when they entered the lower country. The annalist proceeds:

"They [*i. e.* the ancestors of the Cakchiquels] descended finally to Cholumag and Zuchitan. The language there was very difficult, and only the barbarians themselves could speak that language. We spoke only as we had asked the barbarians Loxpin and Chupichin [their captives], and we said on arriving '*uaya, uaya, ela opa.*' The barbarians were greatly astonished to hear us speak their language with the natives of Cholumag; they were really frightened at it; but they gave us only good words."

From these few words, the meaning of which I do not know, it is evident the language was of a totally different stock from Maya or Nahuatl. It was soft and vocalic, like the Xinca; and, indeed, *ela*, tongue (language?), is found in the vocabulary. Unfortunately, Xahila does not tell us the signification of the phrase he gives. It was probably some form of friendly salutation.

But it is not worth while to pursue the inquiry further. These suggestions will indicate the interest which attaches to the Xinca tongue and will, I hope, inspire some one to obtain more complete information about it.

PROC. AMER. PHILOS. SOC. XXII. 118. M. PRINTED FEBRUARY 13, 1885.

Stated Meeting, January 2, 1885.

Present, 12 members.

President, Mr. FRALEY, in the Chair.

Letters of acknowledgment were received from Prof. Alexander Winchell (115); Smithsonian Institution (115); and L'Academie des Sciences, Lisbonne (Trans. N. S. XVI., i., and Proc. 112, 113).

Letters of envoy were received from the Department of the Interior, Washington, D.C., and the Hamilton Association of Canada.

Donations for the Library were received from the Geological Survey of India; the Society of Naturalists at Riga; the Batavian Society of Experimental Philosophy; the Royal Academy of Belgium; the Royal Academy of History at Madrid; the Royal Astronomical Society; Mr. E. W. Maunder, Mr. John Evans and Sir Richard Owen, of London; the Hamilton Association; the Boston Society of Natural History; the American Journal of Science; the Chemical Society of New York; Vassar Brothers' Institute; the Academy of Natural Sciences and the Library Company, of Philadelphia; Dr. Persifor Frazer; Mr. Henry Phillips, Jr.; Haverford College; the American Journal of Philology; Johns Hopkins University; the U. S. Naval Observatory and the Department of the Interior.

A letter was received from Gen. Hazen, Chief Signal Officer, U. S. A., requesting a copy of the Society's Catalogue, which was ordered to be sent.

A letter was received from Alfred Hölder, Vienna, notifying the Society that he could supply the residue of "Die Gasteropoden * *, von R. Hoernes and M. Auinger."

Prof. E. D. Cope made a communication on the Fossils of the Miocene Period of the Dominion of Canada, and exhibited specimens of the same.

Dr. Daniel G. Brinton read a communication entitled "The Lineal Measures of the Semi-civilized Nations of Mexico and Central America."

Pending nominations, Nos. 1031 to 1049 inclusive, were read.

The report of the judges of the annual election was read, and the following officers were declared duly elected for the ensuing year, 1885:

President,

Frederick Fraley.

Vice-Presidents,

E. Otis Kendall, Pliny E. Chase, W. S. W. Ruschenberger.

Secretaries,

George F. Barker, Daniel G. Brinton, Henry Phillips, Jr., J. Peter Lesley.

Councillors for three years,

Aubrey H. Smith, George R. Morehouse, Charles A. Ashburner, Edward D. Cope.

Councillor for one year, in the place of Robert E. Rogers, deceased,

Persifor Frazer.

Curators,

George H. Horn, Philip H. Law, Charles Gordon Ames.

Treasurer,

J. Sergeant Price.

Nominations for Librarian being in order, a letter was read from Prof. J. P. Lesley declining a renomination; whereupon Mr. Henry Phillips, Jr., was nominated for the position of Librarian.

The following resolution was then offered by Mr. J. Sergeant Price:

Resolved, That the members of the Society learn with regret of Prof. Lesley's determination of declining a renomination as Librarian, a position which he has occupied for twenty-two years, and they desire to express to him and to place on record their appreciation of the great value of his services to the Society.

Remarks were made by Messrs. Price, Brinton, Ashburner and the President of the Society, bearing witness to Mr. Lesley's zeal and activity in his office, and expressing their regret that his health and avocations would no longer permit him to continue in his position. The resolutions were then unanimously adopted, and ordered to be engrossed and forwarded to Prof. Lesley.

The Committee of Publication reported in favor of publishing the Dictionary of the Lenapi language, by Zeisberger, at a cost for its preparation not to exceed three hundred dollars. The report was accepted, and the Society ordered the publication of the same, referring to the Finance Committee the consideration of the question of ways and means.

Prof. Cope offered the following resolutions, which were seconded by Dr. Brinton, and adopted:

WHEREAS, The cause of education in science is retarded by the restrictions placed by Congress on the importation of scientific books and apparatus; whereas we believe that advance in the arts and industries depends on the development of science, and is impeded by the before-mentioned import duties, and that all restrictions on education and scientific research are unworthy of enlightened government; whereas the scientific books published abroad are absolutely essential to students and investigators, and are but rarely duplicated in this country; whereas the value of scientific apparatus is in nearly all cases dependent on the individuality of the maker; and whereas colleges and incorporated institutions are now per-

mitted to import apparatus duty free, while private investigators, usually less able to afford expense, are obliged to pay duty, therefore

Be it Resolved, That the American Philosophical Society hereby requests the representatives of the State of Pennsylvania in the Congress of the United States to use all possible efforts to have placed on the free list books pertaining to the physical, natural and medical sciences, and apparatus intended for purposes of scientific research or of education, and further be it

Resolved, That a copy of these preambles and resolutions be forwarded to each member of Congress from the State of Pennsylvania.

And the meeting was adjourned.

Stated Meeting, January 16, 1885.

Present, 20 members.

President, Mr. FRALEY, in the Chair.

Donations for the Library were received from the Mining Department at Melbourne; the Academy of Arts and Sciences at Batavia; the Royal Asiatic Society; the Royal Academy dei Lincei; the Geographical Society at Paris; the Revue Politique; the Meteorological Society and Meteorological Council at London; the Journal of Forestry; London Nature; the Geological and Natural History Survey of Canada; the Boston Society of Natural History; the Museum of Comparative Zoölogy; the American Chemical Society; Mr. R. R. Bowker, New York; Mr. C. E. Beecher, of Albany; the American Journal of the Medical Sciences; the College of Pharmacy; the Franklin Institute; Mr. Henry Phillips, Jr.; Dr. E. W. Syle; the American Chemical Journal; Johns Hopkins University; the Treasury Department; the Chief Signal Office; the United States Commission of Fish and Fisheries; Mr. Jed. Hotchkiss, of Staunton, Va.; and the Minnesota Historical Society.

Mr. Henry Phillips, Jr., deposited in the Library "The Numismatic Chronicle and the Journal of the London Numismatic Society," 1882, Parts 1, 2, 3, 4; 1883, Parts 1, 2, 3, 4; 1884, Parts 1, 2, 3.

Dr. Syle presented the "Common Prayer" in Chinese, published in Philadelphia and printed in New York in 1884; also a Japanese adaptation of Kindergarten songs, published in Tōkio in 1884.

Dr. Curwen read an obituary notice of the late Dr. Thomas S. Kirkbride.

Dr. George A. Koenig presented a communication entitled a "Note on Cosalite, Alaskaïte and Beegerite."

Dr. A. S. Packard, Jr. (of Providence, R. I.), presented (by letter) a communication "On the Embryology of *Limulus polyphemus*, III."

Prof. Pliny E. Chase read a paper "On the Results of an Important Weather Forecast."

Mr. Blasius read a paper "On the Brilliant Sun-glows of the Autumns of 1883 and 1884," which was followed by some remarks by Dr. Syle relative to the well-known sunsets in the tropics and equatorial regions, where moisture was usually most abundant.

Mr. Henry Phillips, Jr., was elected Librarian for the ensuing year.

The following new members were elected:

Prof. Lyman B. Hall, Haverford College, Pa.

Dr. Albin Weisbach, Freiburg, Saxony.

Prof. James W. Moore, Lafayette College, Easton, Pa.

Hon. Samuel J. Randall, Philadelphia.

Hon. George L. Harrison, Philadelphia.

Mr. Frederick Gutekunst, Philadelphia.

Mr. Edward H. Weil, Philadelphia.

Mr. Samuel Wagner, Philadelphia.

Mr. C. Stuart Patterson, Philadelphia.

Dr. Theophilus Parvin, Philadelphia.

Prof. George Inman Riché, Central High School, Philadelphia.

Prof. Francis A. Jackson, University of Pennsylvania, Philadelphia.

Prof. Wm. Osler, University of Pennsylvania, Philadelphia.

Mr. George B. Roberts, President of the Pennsylvania Railroad, Philadelphia.

Mr. Thomas Hockley, Philadelphia.

Dr. James C. Wilson, Philadelphia.

Prof. J. W. Mallet, Jefferson College, Philadelphia.

Prof. Samuel W. Gross, Jefferson College, Philadelphia.

New nomination No. 1049 was read.

The following Standing Committees were chosen for 1885:

Finance,

Henry Winsor, J. Price Wetherill, William B. Rogers.

Publication,

Daniel G. Brinton, Charles M. Cresson, George H. Horn, Persifor Frazer, J. Blodgett Britton.

Hall,

J. Sergeant Price, William A. Ingham, Charles G. Ames.

Library,

Henry Phillips, Jr., Edwin J. Houston, William V. McKean, Thomas H. Dudley, John R. Baker.

The Treasurer presented the annual report of the Trustees of the Building Fund.

And the meeting was adjourned.

The limits of stability of nebulous Planets, and the consequences resulting from their mutual relations.* By Prof. Daniel Kirkwood.

(Read before the American Philosophical Society, November 21, 1884.)

To determine the height of the atmosphere is a problem of no common difficulty. This is evident from the fact that estimates derived from the phenomena of twilight, luminous meteors, and the aurora borealis have been widely various. It cannot extend, however, beyond the limit at which its elasticity is counterbalanced by the force of gravity—a limit probably not less than two hundred miles from the earth's surface. Even the volume and weight of this atmospheric envelope are not absolutely constant, as small quantities of gaseous matter are doubtless brought into it from time to time by meteors and meteoric streams. Nor has this accession of matter from without been the only source of variation; it has been shown by several writers that the extent and density during the cycles of geologic time were in all probability much greater than at present.

But whatever the mass or density of the earth's gaseous envelope, an absolute limit—corresponding to the earth's present time of rotation—may be assigned it. "The atmosphere," says Laplace, "can only extend itself at the equator to the point where the centrifugal force exactly balances the force of gravity; for it is evident that beyond this limit the fluid would dissipate itself." This limit for the earth is 26,240 miles from the centre; for Saturn it is within the system of rings; and for the sun it is at the distance of sixteen millions of miles. These distances, however, were obviously greater before the members of the system had contracted to their

* A preliminary discussion of equation (1) in the following paper was given in the Analyst for January, 1881. Those solutions are here revised, and the results for each planet carefully determined.

Errata in Prof. Kirkwood's Article.

Page 106, erase the comma at the end of l. 2 from top.

" " l. 10 from top, for 489,000,000, read 480,000,000.

Page 111, l. 16 from bottom, for period read periods.

Page 112, l. 7 from bottom, for n' read n^2.

present dimensions. It is now proposed to find their original or maximum values.

In astronomy, as in other branches of physical science, many well-known facts remain still unexplained. This is true not only in regard to the fixed stars and the nebulæ, but within the narrower limits of the solar system. Recognizing the impossibility of accounting for present relations without considering the causes which operated in the distant past, astronomers have attempted to trace the process of formation from the primal chaos down to the origin of the youngest planet. In the theory of Laplace, the planets were formed from nebulous rings successively abandoned in the plane of the solar equator. The present writer, while not rejecting the nebular hypothesis itself, has indicated certain objections to the special form in which it was proposed by its celebrated author.* These difficulties, encountered in the theory of formation from *rings*, are avoided by supposing each planet at its origin to have been separated from a very limited arc of the equatorial protuberance. In either case, however, the dimensions of the primitive planet would be necessarily restricted by the law of gravitation.

It is sufficiently obvious that an original planetary mass in a nebular state could not have retained its continuity of form beyond a certain determinable limit; in other words, that it would have been changed into a ring by the attraction of the central body. The main design of the following paper, after finding in several cases the limits of equilibrium, is to trace, if possible, certain unexplained facts to their origin in these primitive relations between the various members of the solar system.

Limits of Planetary Equilibrium.

If two nebulous bodies, M and m, revolve about a common centre of gravity, the disturbing force of M on the superficial stratum of m is the difference between the attraction of the former on the nearest point of the surface of the latter and that on its centre of gravity. The same is true, *mutatis mutandis*, in regard to the disturbing influence of m on M. If, then,

$a =$ the distance between the centres of M and m, and

$x =$ the distance from the centre of the former to the limit of equilibrium of the latter, we shall have

$\frac{M}{a^2} =$ the attraction of M on the centre of gravity of m,

$\frac{M}{x^2} =$ that on the nearest point of the surface, and

$\frac{M}{x^2} - \frac{M}{a^2} =$ the accelerating force of M on the portion of the surface of m between the two centres; but as these forces from M and m are in equilibrium, the neutral point, or the limit of m, may be found from the equation

* Proceedings of the American Philosophical Society, Vol. xviii, p. 321, and Vol. xix, p. 15.

$$\frac{M}{x^2} - \frac{M}{a^2} = \frac{m}{(a-x)^2} - \frac{m}{a^2} \quad \ldots\ldots(1).$$

Applying this equation to the solar system, x will be the equatorial radius, of the solar nebula, and $a - x$ that of a planet at the epoch of its separation. Putting for simplicity $a = 1$, and reducing,

$$x^4 - 2x^3 + \frac{2M}{M-m}x = \frac{M}{M-m} \quad \ldots\ldots(2).$$

For Jupiter, $m = 1$ and $M = 1048$, hence

$$x^4 - 2x^3 + 2.0019102x = 1.0009551 \quad \ldots\ldots(3),$$

therefore

$$x = 0.92501,$$
$$1 - x = 0.07499,$$
$$(1-x) \times 489{,}000{,}000 = 35{,}995{,}200.$$

Solving equation (2) in like manner for each of the principal planets we obtain the distance from the centre of each to its limit as given in the following table:

Planet.	Dist. to Limit.
Mercury	152,000 miles.
Venus	700,208 "
Earth	1,082,147 "
Mars	764,650 "
Jupiter	35,995,200 "
Saturn	44,887,000 "
Uranus	48,915,000 "
Neptune	81,000,000 "

In these estimates we neglect the eccentricity of the orbits as well as the centrifugal force due to each planet's rotation. The masses and distances adopted are those given in Newcomb's Popular Astronomy, with the exception that for Mercury we have employed a mean between Von Asten's evaluation of the mass $\left(\frac{1}{7{,}636{,}440}\right)$ and the final value given by Leverrier $\left(\frac{1}{5{,}310{,}000}\right)$. The mean is $\frac{1}{6{,}263{,}800}$. For the earth we have taken the sum of the masses of the earth and the moon.

Applying equation (2) to some of the secondary systems we find the following limits of stability:

For the Moon	39,850 miles.
Phobos	6.5 "
First satellite of Jupiter	5,250 "
Mimas	1,500(?) "

Practical Applications.

The results obtained may now be employed in the approximate solution of several interesting problems. The limits of stability will be regarded as the primitive radii of the planets and satellites, as any exterior matter would have been detached by the influence of the central body. To the

primitive relations above developed may we not hope to trace some of the unexplained facts of the solar system? As has been remarked by an eminent writer,* "the plan of the coming universe must have resided in the initial chaos, as certainly as the eagle is in the egg, or the leviathan in its primitive germ."

I. To find the relative mean densities of the earth and moon at the epoch of their separation.

With the notation used in equation (1) the ratio sought will evidently be

$$\frac{\rho M}{x^3} : \frac{m}{(a-x)^3},$$

where ρ = the ratio of the equatorial to the polar radius of the terrestrial spheroid. The value of this ratio is not known. An approximate value may be found, however, by a tentative process.

We have $a = 240{,}300$ miles, $x = 200{,}450$, $a - x = 39{,}850$, $M = 81$, and $m = 1$. Hence the ratio is $0.636_\rho : 1$.

But during the cooling period the ratio of the densities would probably be nearly constant; or, if the moon contracted more rapidly its solidification would occur earlier and the increase of its density practically cease. The present ratio of the mean densities is 5.67 : 3.57, and assuming this to have been constant we obtain

$$0.636\rho : 1 :: 5.67 : 3.57,$$

or,

$$\rho = 2.498;$$

that is, the ratio of the earth's equatorial to its polar radius at the epoch of the moon's separation was nearly 5 : 2, and this may be regarded with some probability as nearly the ellipticity in other cases at the respective epochs of separation.

II. To find the relative mean densities of Jupiter and his first satellite at the epoch of the latter's origin.

Here $a = 260{,}000$ miles, $x = 254{,}750$, $a - x = 5250$; and therefore the ratio is

$$\frac{59240\rho}{(254750)^3} : \frac{1}{(5250)^3} = 0.52\rho : 1,$$

and assuming the constancy of the ratio,

$$0.52\,\rho : 1 :: 121 : 100;\ \text{or, } \rho = 2.33.$$

This value of ρ is nearly equal to that found for the earth; the difference being no greater than might result from the probable error in the elements used.

The present density of Phobos is unknown; but with $\rho = 2.5$, the value found for the earth, the ratio of the original densities of Mars and Phobos was 1.27 : 1. These results seem to indicate that the ratio of the equatorial to the polar radius of the central mass, at the epoch of a planet's or satel-

* Prof. Pierce.

lite's origin, was about 2.5.* With this value of ρ, and the value of x already obtained for each planet, the ratio of the mean density of the solar mass to that of the planets at the respective epochs of their separation would have been as follows:

For Neptune	1.31 : 1
" Uranus	1.31 : 1
" Saturn	1.39 : 1
" Jupiter	1.39 : 1
" Mars	1.25 : 1
" Earth	1.29 : 1
" Venus	1.27 : 1
" Mercury	1.22 : 1

From these numbers we infer that central condensation had commenced in the solar nebula before the origin of Neptune, and that the ratio of the mean density to the density of the equatorial parts near the surface was approximately the same at the successive epochs of planetary formation.

Were the Planets formed from nebulous Rings?

If the original solar mass, like most nebulæ, was irregular in form, the first matter detached would not probably be a ring, but a nebulous planet. As condensation advanced, the centrifugal force would increase until approximately equal to the central attraction. The disturbing influence of the planet already formed would produce, when in perihelion, an increasing tidal-wave, resulting in the separation of a second planet. The origin of other planets is accounted for in like manner. If, in the ancient history of the system, nebulous matter, left at first exterior to the orbit of a new planet, should subsequently fall upon the central body, the effect would be not only a shortening of the period, but probably also a lessening of the orbit's eccentricity.

III. *The Peculiar Relations of the Martian System.*—Professor Pickering estimates the diameter of Phobos at seven miles.† Adopting this value, and supposing the ratio between the densities of Phobos and Mars equal to that between the moon and the earth, we shall find the limit of the satellite's equilibrium to be 6.5 miles from its centre, or three miles from its surface. Were the density reduced to that of Saturn, the limit would be almost exactly at the surface; or, with a density equal to that of Mars when the radius of the latter was that of the satellite's orbit, the limit would be at a considerable distance within the surface. Since, therefore, the satellite could never have existed at its

* It was shown by Laplace that a rotating homogeneous fluid cannot retain its spheroidal form when ρ is greater than 2.7197. Mec. Cel. III, *iii*, §20 [1605'], Bowditch's Trans. The ratio would be less in the case of central condensation.

† Annals of the Observatory of Harvard College, Vol. xi. Professor Seth C. Chandler makes the diameter still less. See Sci. Obs. for Sept., 1877.

present distance in a nebular state, it must follow, if any form of the nebular hypothesis is to be accepted, that its original distance was greater than the present. Can we assign a probable cause for this ancient disturbance?

Of the eight major planets, Mars has the most eccentric orbit, except that of Mercury; its perihelion distance being 13,000,000 miles less than its mean distance. This difference, in fact, amounts to 20,000,000 miles when the orbit of Mars has its greatest eccentricity. If, therefore, the radius of the sun, or of the solar atmosphere, was somewhat greater than the least distance of Mars at the commencement of the latter's separate existence, the planet in perihelion would pass through the outermost equatorial zone of the solar nebula. This resisting medium would not only accelerate the motion of Mars, but also, in a much greater degree, that of his extremely small satellites. The solar volume, meanwhile contracting more rapidly than the orbit of Mars, would finally leave the latter moving in an eccentric path, without sensible resistance.*

IV. *The Saturnian System.*—For Mimas, the first satellite of Saturn, the most probable values of the mass and density give the distance of the limit from the satellite's surface less than the radius of Mimas. The rings of Saturn, in all probability, could not exist as three satellites, the limits of equilibrium being interior to the surface. This is true at least in the case of the innermost ring. Analysis seems to indicate that PLANETS AND COMETS HAVE NOT BEEN FORMED FROM RINGS, BUT RINGS FROM PLANETS AND COMETS. If, without any loss of mass, the density of a planet were diminished until the radius should exceed the limit of equilibrium, what change would take place in the planetary form? Evidently a portion of the matter nearest the central body would be separated from the rest, and, as the orbital velocity would be less than that corresponding to its distance, it would move in a new ellipse, the aphelion of which would be the point of separation.

V. *Comets.*—The effect of the sun's attraction in the dismemberment of comets is well known to astronomers. The nuclei of the large comets of 1680, 1843, 1880 and 1882 must have had great force of cohesion between their parts, in order to withstand the tendency to disintegration at the times of perihelion passage. Had the nuclei been either liquid or

* This view was first presented in the Observatory for January, 1878. Different explanations of the short period of Phobos have been proposed by astronomers, but none, perhaps, entirely free from difficulties. One distinguished writer has suggested that $7^h\ 39^m$, the period of Phobos, was the rotation period of Mars at the epoch of the satellite's origin, and that the lengthening of the period to $24^h\ 37^m$ has been due to retardation by solar tides. But it is well known that the time of rotation of a planet in the process of condensation varies as the square of its radius. The resulting period of Mars, therefore, on reaching its present dimensions, would have been but a small fraction over one hour. This period, it is true, would have been somewhat modified by the counteracting influence of the solar tides; but the hypothesis referred to seems wholly inadequate to meet the objection derived from equation (2).

gaseous, or even clusters of solid meteorites, the difference between the sun's attraction on the central and the superficial parts would have pulled the comets asunder, spreading out the fragments into somewhat different orbits, like the meteoric streams of August and November.

This view of the gradual dispersion of comets in perihelion is in striking harmony with the facts of observation. The comets of short period have not only been divested of tails, which in all probability they originally possessed, but they seem to be losing more and more of the cloud-like matter which surrounds their nuclei. Halley's comet has lost much of its ancient splendor, and, had its period been no greater than that of Encke's or Biela's, it might long since have been reduced to a telescopic magnitude. The separation of Biela's comet, in 1845, was not the beginning of that body's dismemberment. We have evidence that this process had commenced before 1798, as in that year a meteoric shower, produced by its *débris*, was observed in Europe. A shower derived from the same group was again seen in 1838.* Before 1845, however, the separated fragments were too small to be individually recognized. How far the sun's action alone can explain the facts, it may be impossible to determine.

VI. *The Zodiacal Light.*—Original small planets near the sun, in a nebular or gaseous condition, would probably be transformed either into rings or meteoric clusters, the scattered particles of which, reflecting the sun's rays, would present an appearance like that of the zodiacal light.

VII. *Origin of the Asteroids.* — In the primitive condition of a planet, immediately after its separation from the central mass, not only would the latter cause a considerable elongation of the former in the direction of the line joining their centres, but the planets also—especially the larger—would produce great tidal elevations on the sun's surface. Now, a comparison of the elements of Hilda and Ismene, the 153d and 190th asteroids, shows them to be an isolated pair whose periods are very nearly equal, each exceeding the longest in the interior cluster by more than fifteen months. Jupiter's limit of equilibrium, when in the nebular form, was immediately beyond the orbits of these minor planets. If the sun once extended to the aphelion distance of Hilda (4.632), the central attraction of his mass on a particle of the equatorial surface was but five times that of Jupiter at the point to which he was vertical.† The centrifugal force due to the sun's rotation would be greatest at the crest of this tidal wave, produced by Jupiter, so that parts might become separated from the solar mass, and transformed into asteroids. It is to be further remarked that two periods of Jupiter are approximately equal to three of Hilda and Ismene, that is, to three rotation periods of the sun at the epoch of their separation. The disturbing effect of the "giant planet" on the tides of the central body would therefore be increased at each perihelion passage.‡

* Humboldt's Cosmos, Bohn's ed., Vol. iv, p. 582.

† Jupiter's perihelion distance is 4.95.

‡ The longitude of Ismene's perihelion differs from that of Hilda's by 180°.

The process would be similar when one period of Jupiter was equal to two rotation periods of the central nebula.

VIII. *The Rotations of the Planets.*—It is well known that the analogy between the periods of rotation of the primary planets, as published by the present writer several years since, assigned a much longer period of rotation to Uranus than to Jupiter or Saturn. But as that of Uranus had not been measured, and the observations of the polar compression were by no means accordant, the fact was not then thought incompatible with the proposed law of rotation. Recent measurements, however, leave no room to doubt that the ellipticity is even greater than that of Jupiter, and consequently that the planet moves rapidly on its axis. The law connecting the rotation periods must accordingly require an important modification.

In a planet having a constant mass, with a variable volume, the time of rotation varies as the square of the radius. It is easy to show, however, that this law could not have obtained from the origin of the solar system. For instance, in tracing backward the history of the earth, we find that when the radius was 8000 miles, its rotation period, according to this law, was 96 hours; when the former was 12,000 miles, the latter was 216 hours; and, finally, if the earth ever extended to the moon's orbit, the time of rotation, by the same law, instead of having been equal to the moon's orbital period, was nearly ten years. So likewise when Mars filled the orbit of Phobos, his rotation period was 7 days and 16 hours, or 24 times the orbital period of the satellite. We conclude, therefore, that during the earlier stages of its condensation all parts of the mass did not rotate in the same time. It is easy to see, in fact, that tidal retardation must have been much more effective at the surface than in the interior of a large planet in the gaseous state.

In so far as we know, the rotation period of the smaller planets, Mercury, Venus, the Earth and Mars, are nearly two and a half times those of the larger and more remote. What cause can be assigned for this remarkable difference? In other words, why did the process of condensation continue longer in the large and less dense planets exterior to the asteroids than in the small bodies nearer the sun? It may be answered in a general way that in small and dense planets solidification would occur at a comparatively early epoch in their history, and hence the acceleration of their rotary velocity would be, in a large measure, arrested. It seems probable, therefore, that, while the same law of rotation may obtain between the members of each separate group, it cannot apply where one of the planets is in the inner and the other in the outer cluster.

As regards their axial movements, the solar system appears to contain at least three distinct classes of planetary bodies; the obvious characteristics of each being traceable to their relative primitive densities. These are as follows, the primitive density of Neptune being taken as unity:

I The large planets:

	Primitive Density.
Neptune	1.0000
Uranus	3.8950
Saturn	32.7073
Jupiter	210.7440

II. The planets interior to the zone of asteroids:

Mars	7,446.4
Earth	24,880.5
Venus	70,129.2
Mercury	468,616.0

III. The secondary planets, of which our moon and Jupiter's first satellite may be taken as types:

Jupiter's first satellite	2,600,000
The Moon	4,820,000

There is, we may remark, an antecedent probability that the law truly formulated will assign to Saturn a period of rotation somewhat less than the period observed; as it is sufficiently obvious that if the ring had remained an integral part of the planet, the resulting time of rotation would have been, in fact, sensibly shorter than the present. It is also to be remembered that the late observations of Denning and Schiaparelli make Mercury's time of rotation nearly 25 hours. In the case of the satellites, the equality between the periods of rotation and revolution was established at an early epoch in their history. No further decrease in the time of rotation was therefore possible.

A comparison of the quantities used in equation (1) suggests that a planet's time of rotation is a function of its mass, distance, and primitive density. The form of this function—found by a tentative process—may be expressed as follows:

The square of the number of a planet's days in its year is to that of any other of the same group, as the primitive density of the latter is to that of the former; that is,

$$n^2 : n' :: \triangle' : \triangle; \text{ or, } n' = n\left(\frac{\triangle}{\triangle'}\right)^{\frac{1}{2}} \quad \ldots\ldots (4),$$

where

$$\triangle = \frac{m}{R^3} = \text{the primitive density, and}$$

$$n = \frac{T}{t} = \frac{\text{orbital period}}{\text{rotation period}} = \text{the number of a planet's days in its year.}$$

Equation (4) may be reduced to

$$t^n : t'^n :: m\left(\frac{d}{R}\right)^3 : m'\left(\frac{d'}{R'}\right)^3 \quad \ldots\ldots (5),$$

where d, d' and R, R′ are the respective distances and primitive radii.

The Outer or less dense Group.

In the following table the rotation periods of Saturn, Uranus and Neptune are derived from that of Jupiter by formula (4).

Planet.	m	R	Δ	T	t	n
Neptune.	16.86	81,000,000 m	1.0000	60,126.71 d	9 h 35 m	150,751.80
Uranus..	14.46	48,915,000	3.8950	30,686.82	9 33	77,186.00
Saturn...	93.84	44,887,000	32.7073	10,759.219	9 43	26,630.00
Jupiter..	311.80	35,995,200	210.7440	4,332.584	9 55	10,492.64

It will be noticed that the theoretical period of Saturn is 31 minutes less than Hall's evaluation.

The Inner Group.

Planet.	m	R	Δ	T	t			n
					h	m	s	
Mars	0.1056	764,650 m	7,446.40	686.98 d	24	37	23	669.57
Earth....	1.0000	1,082,147	24,880.5	365.26	23	53	48	366.84
Venus...	0.7690	700,208	70,129.2	224.70	24	42	54	218.18
Mercury.	0.0522	152,000	468,616.0	87.97	25	0	46	84.405

Here the rotation periods of the earth, Venus and Mercury are derived from that of Mars by formula (4). The first is two minutes less than the true period; the time of Venus's rotation is doubtful; and the theoretical determination of Mercury's period agrees with the estimate of Mr. Denning.

PROC. AMER. PHILOS. SOC. XXII. 118. O. PRINTED MARCH 5, 1885.

Notes on the Geological Structure of Tazewell, Russell, Wise, Smyth and Washington Counties of Virginia. By John J. Stevenson, Professor of Geology in the University of the City of New York.

(*Read before the American Philosophical Society, November 21, 1884.*)

Introduction.

I. Geological Structure: the Faults and Anticlinals.
II. The Several Groups.
III. The Area drained by Holston River.
IV. The Area drained by Clinch River.
V. The Salt and Gypsum Deposit of the Holston Valley.

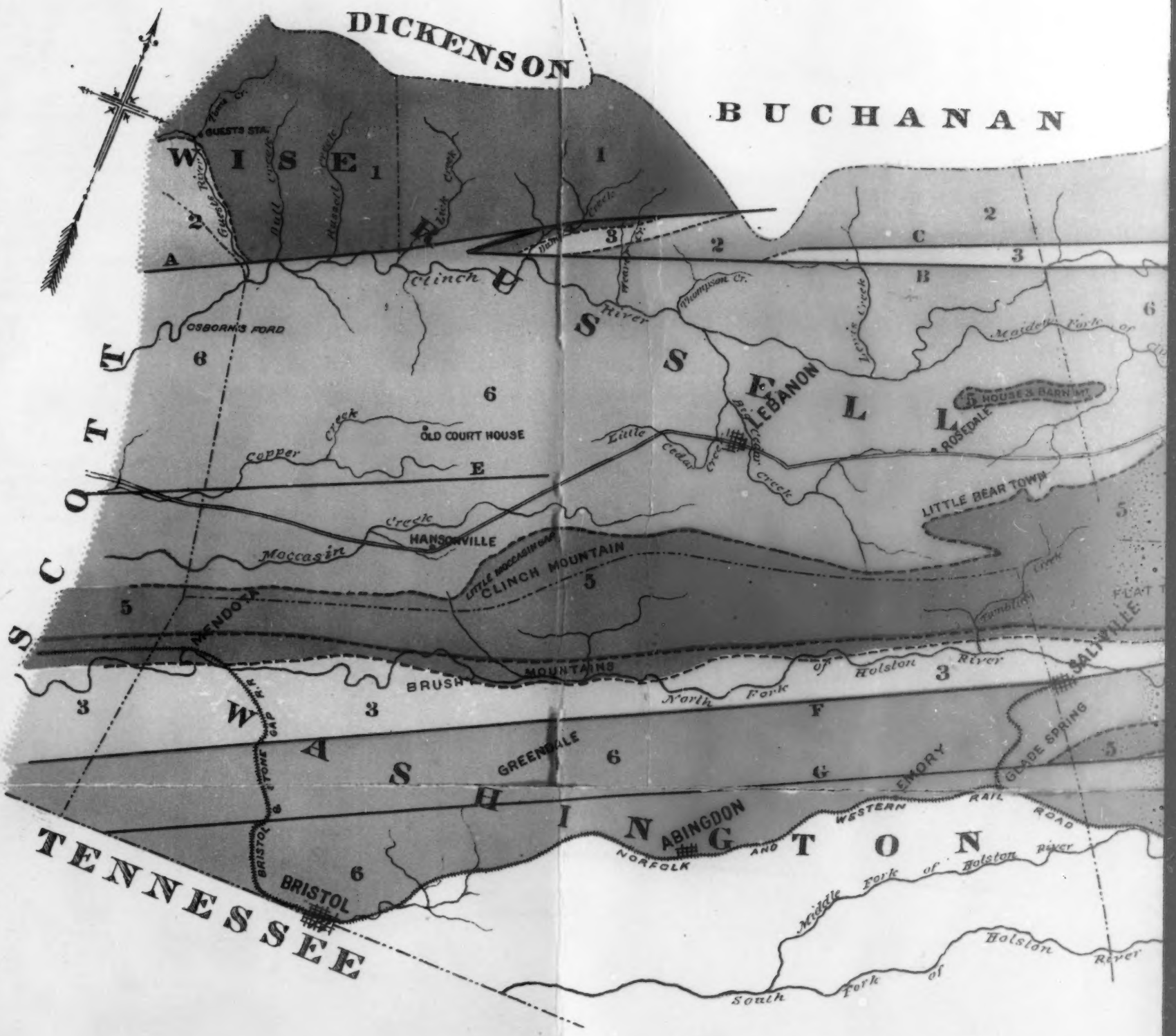
INTRODUCTION.

This memoir is practically a continuation of the writer's memoirs on southwestern Virginia, read before this Society in August, 1880, and in January, 1881. In it the description is carried eastward so as to connect with the reconnaissance work described in the writer's memoir, read in October, 1881. This, however, differs from those in that it contains no references to economic geology except in so far as may be needful to the explanation of structure.

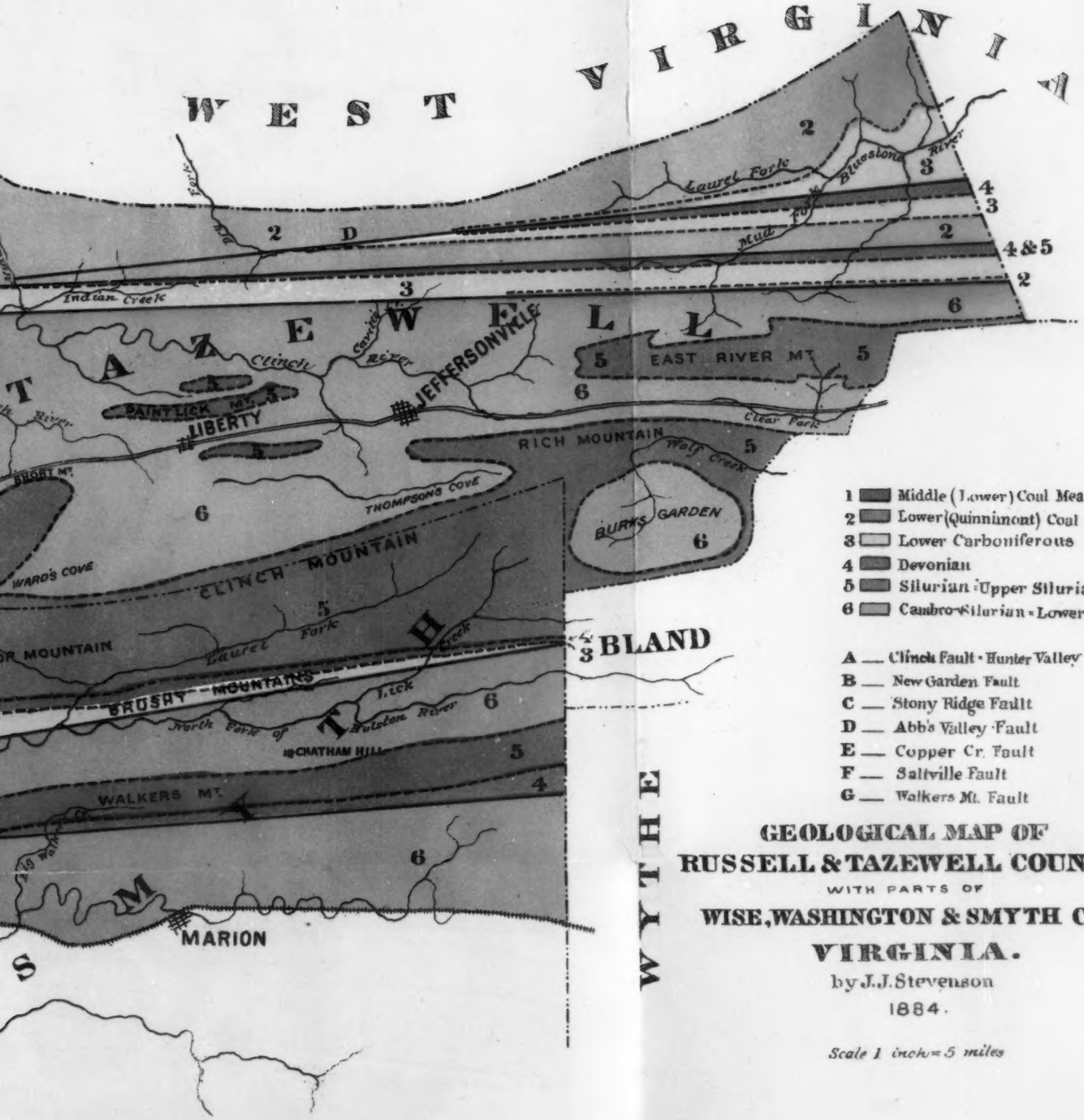
Little has been published respecting the geology of this region, the only memoir of material importance being that by Prof. J. P. Lesley, read before this Society in 1871.* The writer is indebted to this for some useful information, which will be acknowledged fully in its proper place. A note in *Science* by Mr. E. G. Squier, makes one wish that that observer had published more of his work. Brief notices of the Saltville basin and vicinity have been published by Profs. W. M. Fontaine and C. H. Hitchcock, but these give little of detail.

Like the region described in the writer's previous memoirs, this shows no monotony of surface. The Great valley of Virginia, with its floor of Cambro-Silurian rocks, occupies a great part of Washington and Smyth counties, and has as its north westerly boundary the irregular Walker mountain. That mountain is a low ridge of limestone in Washington county, but in Smyth county it becomes double, consisting of a Medina ridge, Big Walker, separated by a Clinton valley from the Devonian ridge, Little Walker, which overlooks the valley. Rich valley separates Big Walker mountain from Brushy mountain, a ridge of Devonian and Lower Carboniferous, which is separated by a narrow and somewhat indefinite Poor valley from Clinch mountain, these two ridges bearing the same relation as Big and Little Walker. There is then a succession of "Poor" and "Rich" valleys; the latter, with limestone soils, are either

*Lesley. The Geological Structure of Tazewell, Russell and Wise Counties in Virginia. Read April 21, 1871.


DICKENSON
BUCHANAN
WISE
TAZEWELL
SCOTT
WASHINGTON
TENNESSEE
GUEST'S STA.
Guest River
Dull Creek
Russell Creek
Clinch River
Thompson Cr.
Lewis Creek
Maiden Fork of
OSBORNS FORD
OLD COURT HOUSE
Copper Creek
LEBANON
Little Cedar Creek
ROSEDALE
LITTLE BEAR TOWN
HANSONVILLE
Moccasin Creek
CLINCH MOUNTAIN
MENDOTA
BRUSH MOUNTAINS
North Fork of Holston River
SALTVILLE
Tumbling Creek
FLAT
GLADE SPRING
EMORY
GREENDALE
ABINGDON
WESTERN
RAIL
ROAD
NORFOLK AND
Middle Fork of Holston River
South Fork of Holston River
BRISTOL
STATE LINE
BRISTOL
A
B
C
E
F
G

BUCHANAN
1
2
3
C
B
6
5
Thompson Cr.
Levis Creek
Maiden Fork of Clinch River
S River
LEBANON
HOUSE & BARN MT.
ROSEDALE
BROAT MT.
Little Cedar Creek
Big Cedar Creek
LITTLE BEAR TOWN
WARD'S COVE
FLAT TOP MOUNTAIN
Tumbling Creek
SALTVILLE
North Fork of Holston River
F
GLADE SPRING
6
G
EMORY
ABINGDON
WESTERN RAIL ROAD
NORFOLK AND
Middle Fork of Holston River
Holston River
South Fork of



1 Middle (Lower) Coal Measures
2 Lower (Quinnimont) Coal Measures
3 Lower Carboniferous
4 Devonian
5 Silurian - Upper Silurian
6 Cambro-Silurian - Lower Silurian

A — Clinch Fault - Hunter Valley Fault
B — New Garden Fault
C — Stony Ridge Fault
D — Abb's Valley Fault
E — Copper Cr. Fault
F — Saltville Fault
G — Walkers Mt. Fault

GEOLOGICAL MAP OF RUSSELL & TAZEWELL COUNTIES

WITH PARTS OF

WISE, WASHINGTON & SMYTH COS, VIRGINIA.

by J. J. Stevenson

1884.

Scale 1 inch = 5 miles

Lower Carboniferous or Cambro-Silurian, while the former are either Silurian or Devonian. *The* Poor valley is that which follows the southerly foot of Clinch mountain from far beyond the Tennessee line north-eastward into Bland county. *The* Rich valley is that which lies along the northerly foot of Walker mountain, rudely following the Saltville fault to just beyond Saltville.

The region between Clinch mountain and Clinch river shows many broad "bottoms," and much handsomely rolling land. The immediately underlying rocks are Trenton and Knox in most of the region, but toward the eastern end strips of Hudson and Medina are held in narrow synclinals, and form short ridges which are striking features of the scenery.

Two limestone ridges, Copper and Moccasin, are persistent.

The whole area is fairly well watered, though in those parts directly underlaid by limestone springs are apt to be uncertain, as the waters frequently disappear through newly made crevices in roofs of caverns, where they join underground streams, which occasionally break forth with enormous volume. The principal water ways are the Clinch and the two forks of the Holston. The Clinch, rising in eastern Tazewell, drains nearly the whole of that county and Russell with much of Wise. Its important tributaries from the south are the Maiden Spring fork in Tazewell and Copper creek, which, rising in Russell, enters the river in Scott county. The tributaries from the north are numerous, but, with the exception of Guest's river in Wise county, they are very short. Bluestone river and Wolf creek, draining the eastern part of Tazewell, flow to the New river. The North fork of the Holston river rises in Bland county not far east from the Smyth county line and drains the space between Walker and Clinch mountains, with a narrow strip north from Clinch mountain in Scott and Russell counties. The South fork of Holston drains the Great Valley. The Clinch and Holston unite in Tennessee to form the Tennessee river.

Only the southern part of the area under consideration has railroad facilities. The Norfolk and Western Railway follows the valley; its New River branch, passing through Pulaski and Giles counties of Virginia and Mercer county of West Virginia, reaches the extreme north-east corner of Tazewell county at the Pocahontas mines; its Saltville branch extends from Glade Spring to Saltville. A railroad to extend from Bristol to the Big Stone gap in Wise county has been graded from Bristol to Mendota, about sixteen miles, but no work has been done on it for some time. Clinch mountain makes very difficult access from the valley to the region beyond, for, in its whole length of more than 100 miles from the Tennessee line to the eastern edge of Bland county, there is but one water gap, and only one wind gap which affords easy grades for a wagon road. The former, Big Moccasin, has been taken for the Bristol and Stone Gap road, and the other, Little Moccasin, has been occupied by a survey for the Norfolk and Cincinnati Railway Company. This is a difficult pass for railway operations, but Mr. Oramel Barrett, Jr., has succeeded in locating

an available line through it. Some conception of the difficulties to be overcome by a road in passing from the valley to Clinch river may be had, when one remembers that in that interval the line must cross Walker mountain, Rich valley, Brushy mountain, Poor valley, Clinch mountain, and the irregular limestone ridges of Tazewell county. Roads have been projected and survey lines run across the headwaters of streams entering Clinch river from the north, having for object the passage into Kentucky. None of these has advanced beyond the preliminary surveys.

Several wagon-roads with good grades were constructed many years ago by State aid, and some excellent pikes were constructed by private companies. The engineering of the Tazewell pike and of the Hayter's Gap road as they cross the abrupt Clinch mountain is remarkably good. The grades of the Fincastle pike passing through the county seats of Tazewell, Russell, Scott and Lee on the way to Cumberland gap are very easy. The common roads, as in too many other parts of our country, are far from being good; often a very fair wagon road terminates suddenly in a mere trail with almost impassible grades. The traveler finds horseback the more comfortable as well as the more expeditious mode of conveyance.

The especial industries of the region are grazing and tobacco culture. The limestone soils yield grass equal to that of Kentucky, and beef cattle from the ridge land of Russell and Tazewell are thought to be equal to those from any other region of our country. The timber is superb, walnut, poplar, oak, ash and hickory being still plentiful beyond Clinch river. The mineral resources are important. Brown hematites occur at many localities; fossil ore is present in greater or less quantities on Big Walker, Clinch, Paint Lick, Rich and East River mountains; oxide of manganese was seen on Rich mountain and Copper ridge; barium sulphate is present at times in considerable quantity; the Estilville marbles are of the finest quality and in almost unlimited quantity; salt and gypsum of great excellence are found in the valley of the North Holston; north from the Clinch river is the great coal field, containing in Tazewell and part of Russell the soft coking coals of the Quinnimont group or Lower Coal measures, while in western Russell and in Wise county, north from Stone mountain, are the harder coals, the shipping coals of the Middle Coal measures. For the present, however, none of all these resources, agricultural and mineral, is available, except that of converting grass and grain into beef, the cost of transportation destroying the value of the rest.

The following lists of altitudes have been supplied to me by the gentlemen whose names precede the lists:

Altitudes on and near the Line of the Norfolk and Cincinnati Railroad. From Oramel Barrett, Jr., Chief Engineer.

Elevations above mean tide at Norfolk, Virginia, all taken with the level, except a few by barometer which are specially indicated.

Washington County.

Abingdon station, sub-ballast on N. and W. R. R. ... 2056.8

Walker Mountain summit, on turnpike from Abingdon to Liberty..... 2145
Low water, N. F. of Holston, mouth of Little Moccasin creek, barometer..... 1430
Same at mouth of Wolf creek, below Saltville..... 1508
Little Moccasin gap, summit on line between Washington and Russell counties..... 2377
Clinch Mountain summit, one mile N. E. of Little Moccasin gap, by triangulation; is about average altitude of the crest for nine miles north-east to near Hayter's gap..... 4244
Clinch Mountain summit (Rich mountain), at head of Stuart run..... 3264
Hayter's gap in Clinch mountain..... 3025

Russell County.

Divide between Big Moccasin and Little Cedar creeks, close to Abingdon and Lebanon pike..... 2341
Little Cedar creek just below Mr. Brown's milldam, three miles south from Lebanon..... 2090
Dickersonville, in front yard of dwelling between house and store..... 2043
Summit of Copper ridge near Wise C. H., road at head of Copper and Ocean Cove creeks..... 2288
Fincastle pike, eastern base of Copper ridge, one mile and a half N. E. from Dale Carter place..... 2075
Summit of Copper ridge in public road at head of Jesse or Mill branch..... 2226
Springs at head of Jesse branch..... 2025
Surface of low water in Clinch river at mouth of Dump creek..... 1480.5
Grissell coal bed on Dump creek..... 1720
Eastern base of Sandy ridge at head of Hurricane fork of Dump creek..... 2000
Gap in Sandy ridge at head of Hurricane fork of Dump creek, and Caney fork of Indian creek, the latter flowing into Russell fork of Big Sandy river.. 2302
Sandy ridge, approximate average elevation of, for several miles east and west from the above-mentioned gap..... 2600
High knob on Sandy ridge, back of ex-Sheriff James Kiser's house, at head of Dump and McClure creeks, barometer..... 3100
Bower's gap in Sandy ridge at head of Weaver and Indian creeks..... 2300
Little Cedar creek in front of Lebanon..... 1970

Surface water in mill-dam, Big Cedar creek at Elk Garden 2120
In public road in front of residence of Mr. W. A. Stuart, on Big Cedar creek 2170
War gap, in spur of Clinch mountain, drained by branch of Big Cedar creek. 2500
In meadow, front of Rosedale store, looking toward Big Cedar creek. 2330
Front of E. R. Baylor's store, on divide between Big Cedar creek and North fork of Indian creek of Maiden Spring fork 2448
Clinch river at mouth of Lick creek 1404.5
Same at mouth of Jim Jack creek, above Lick creek.. 1408

Dickenson County.

Surface of low water in Russell fork of Big Sandy river at mouth of Indian creek 1415
Same at mouth of Frying Pan creek 1266.6
Same at mouth of McClure creek. 1240.5
Same at the mouth of Pound fork 1170
Same in the "Breaks" at the base of the highest "tower," two and three-fourths miles from the Kentucky line. 1060
Same at Kentucky line by barometer. 850

Wise County.

Summit of Whetstone Mt., 200 feet north from Wise Court House road, between Russell and Whetstone creeks 1843
Surface of water in Russell creek, one-fourth mile below R. Dickenson's house, directly below mouth of Little Russell creek 1530
Summit of Bull hill, between Russell and Bull creeks, close to Wise Court-House road 1910
Surface of water at junction of Little and Big Bull creeks 1425
Summit between Dry fork of Bull creek and Crab Orchard creek 2097

Elevations in Southwest Virginia, by South Atlantic and Ohio Railroad levels, reduced to tidal elevations, taking Bristol, Tenn., on Norfolk and Western Railroad, at 1670 feet above tide. John C. Oliphant, Superintendent and Engineer.*

Washington County.

Bristol 1670
Summit of Walker mountain. 2077
N. F. Holston river at Mendota 1325

* In the body of this memoir, this road is referred to as the Bristol and Stone Gap R.R.

Scott County.

Moccasin gap in Clinch mountain	1233
Summit at Troublesome creek	1565
Clinch river at Spear's ferry	1185
Flat Lick summit	1540
Slemp's gap, end of Powell mountain	1320

Wise County.

Wild Cat summit	1905
Mineral city	1550
Big Stone gap	1555
Divide between Powell and Guest's rivers	2160
Guest river, near Lost creek	2090

Dickenson County.

Divide between Guest's and Pound rivers, at head of Indian creek	2605
Mouth of Indian creek of Pound river	1513
Big Sandy river at Kentucky line	854

I. THE GENERAL STRUCTURE.

As is already familiar to those who have read Prof. Lesley's memoir of April, 1871, or that of January, 1881, by the writer, the especial interest attaching to Southwest Virginia lies in the great faults or cracked anticlinals which have so great extent both longitudinally and vertically. So far as known to the writer, the existence of these faults was first indicated by Prof. W. B. Rogers in his earliest report on the geology of Virginia,* three principal faults being shown on the long cross-section. The existence of the Saltville and New Garden faults is asserted in a paper on Thermal Springs by the same author and in a long memoir on the structure of the Appalachian Chain by Profs. W. B. and H. D. Rogers.† Some of these faults are very simple in structure, but others are sufficiently complex. Groups of anticlinals occur, canoe-shaped and overlapping, thus reproducing the features so characteristic of Silurian and Cambro-Silurian areas of Central Pennsylvania.

The structure may be considered most conveniently by going from the Great Valley northward to the Coal Measures area, taking the more prominent features in order as follows:

The Fault of Walker mountain.
The Saltville fault.
The Clinch Mountain group of folds.

* W. B. Rogers. Report of the Geological Reconnaissance of the State of Virginia. 1836.

† These papers are contained in the volume of Transactions of the Association of American Geologists and Naturalists. 1840-42.

The Copper Ridge fault and the Elk Garden anticlinal.
The House and Barn synclinal.
The Clinch River system of faults.
The Stone Mountain anticlinal.

The Fault of Walker Mountain.

The Great Valley of Virginia extends in Washington and Smyth counties from Walker mountain south-eastwardly to the limit of those counties. It is underlaid by Cambro-Silurian rocks whose calcareous beds have yielded readily to erosion. The dip is undulating, and one well-marked anticlinal is crossed frequently by the turnpike between Seven-mile ford and Bristol.

The fault of Walker mountain is clearly the same with that which is termed the *South Fork of Holston Upthrow* on Prof. Lesley's map of 1871. As, however, it nowhere approaches the South fork of Holston, the writer prefers to retain the name applied to it in his memoir of 1881. It is wrongly placed on the map accompanying that memoir, though its position is given rightly in the text as at about four miles from Bristol. The error arose from a misunderstanding respecting the true place of Walker mountain, so that on that map, this fault occupies very nearly the place of the Saltville fault.

This fault, in much of Washington county, brings the Trenton limestone into contact with the lower part of the Knox group. Where it is crossed between Bristol and Mendota cannot be determined accurately without detailed study, but the course is shown approximately by a rather low ragged ridge of limestone which can be followed without difficulty to the eastern edge of Washington county. The line of fault is crossed by the Saltville branch of the Norfolk and Western Railroad at the water station, somewhat less than two miles from Glade spring. Thence the downthrow rapidly increases, and within two miles the ragged ridge of limestone becomes Walker mountain with Medina and Clinton, the fault line passing just north from Washington springs. The downthrow continues to deepen, Devonian is held on the northerly side of the fault, and the mountain is divided into Big and Little Walker, Medina and Chemung ridges, separated by a valley of Clinton and Hamilton. This structure is well shown on Chilhowie creek, though at the place of the fault, nearly three miles north from the railroad, everything is wholly concealed. It is altogether probable that the lowest beds of the Lower Carboniferous are held on the north side of the fault toward the eastern edge of Smyth county, for in the adjoining county of Wythe Vespertine coal beds occur and they have been worked. Unfortunately one cannot determine with equal ease the changes which take place on the southerly or upthrow side of the fault; the Knox limestones have yielded to erosion and solution and for the most part their surface is deeply buried under débris. There is no room for doubt, however, that

the cherty beds of the Knox, which weather with a fretted surface, are exposed along the southerly side as far eastward as the Saltville railroad.

Northward from the fault of Walker mountain the sequence is regular until, at a distance of about four miles, the

Saltville Fault

is reached. This was designated in the writer's previous memoir as the fault of the *North Fork of Holston*, the name applied to it by Prof. Lesley. That observer having touched this fault only near Saltville, naturally applied to it the name of the river by which it is crossed more than once in that neighborhood. But, as will be shown, that name is misleading, and "Saltville" is much preferable, as the line of the fault passes through the widely known village of that name.

This fault is crossed by the Bristol and Stone Gap Railroad grade within a few rods north from the Rich Valley road and only a little way south from the deep cut on Wolf Run summit. Its place is wrongly indicated on the writer's earlier map, on which it should be very nearly where the Walker Mountain fault has been placed. The course of the fault eastward from the railroad is almost straight to Saltville on the border of Smyth county. It passes through that village not many yards from the salt-shaft: it lies between the Broadford road and the river; is crossed by the latter probably twice within six miles east from Saltville, and is again crossed or touched by it at ten miles from Saltville; it is crossed by Cove creek at a little way north from I. H. Buchanan's house and by Lick creek at only a little way north from the Saltville and Sharon Springs road. Beyond ten miles eastward from Saltville, that road lies south from the fault.

The North fork of Holston rises in Bland county, follows a very serpentine course through Knox and Trenton limestones for fifteen or twenty miles, and touches the Saltville fault at ten miles east from Saltville. Thence until very near the Broadford, six miles from Saltville, the river is south from the fault, but in the next three miles the fault is crossed certainly more than once. At somewhat more than three miles east from Saltville the river crosses to the northerly side of the fault, finally. Within Washington and Scott counties the river bed and the fault are from two to five miles apart, with the clumsy Brushy mountain occupying the interval. In a distance of seventy or eighty miles the North fork of Holston crosses or touches the Saltville fault not more than four times, all of them within a space of eight miles; while during the rest of its flow through Bland, Smyth, Washington and Scott counties it is from one to five miles either north or south from the line of fracture. Its course seems to be dependent on neither the fault nor the character of the rocks for it is serpentine alike through the yielding limestones of the Trenton, the refractory sandstones of the Knox, the hard and soft limestones of the Lower Carboniferous, the soft shales and hard sandstones of the Lower Carboniferous, Devonian and Silurian.

The relation of the Saltville fault to the Burk's Garden anticlinal of the

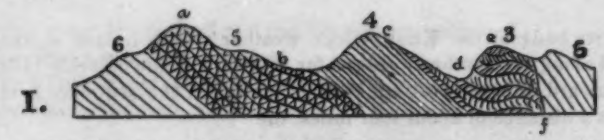


FIG. I.—From Moccasin creek to the Saltville fault beyond Wolf Run summit. *a*, Clinch Mt. *b*. Poor valley. *c*, Brushy Mt. *d*, N. F. of Holston river. *e*, Wolf Run summit. *f*, Saltville fault. *3*, Lower Carboniferous. *4*, Devonian. *5*, Silurian. *6*, Cambro-Silurian.

FIG. II.—From Pinnacle pike to the Saltville fault through Hayter's gap. *a*, Clinch Mt. *b*, Poor valley. *c*, Brushy Mt. *d*, N. F. of Holston river. *f*, Saltville fault. *m*, southerly slope of Elk Garden anticlinal. *n*, Loop anticlinal. Numbers as in Fig. 1.

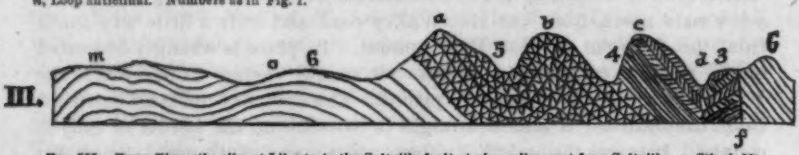


FIG. III.—From Pinnacle pike at Liberty to the Saltville fault at nine miles west from Saltville. *a*, Clinch Mt. *b*, Flat Top Mt. Burk's Garden anticlinal. *c*, Brushy Mt. *d*, N. F. Holston river. *f*, Saltville fault. *m*, Elk Garden anticlinal. *o*, Cove anticlinal. Numbers as in Fig. 1.

FIG. IV.—Apparent structure of Clinch fault at gap of North fork of Clinch river, through Buckner's ridge. *f*, Fault. Numbers as in Fig. 1.

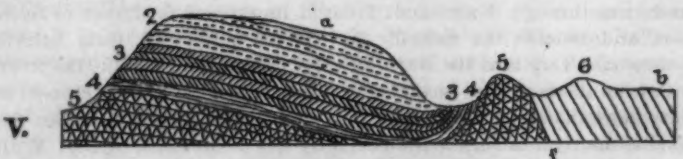


FIG. V.—Cross-section along Stony creek, through Powell mountain and Buckner's ridge. *a*, Powell-Stone Mt. *b*, Buckner's ridge. *f*, Clinch fault. *2*, Lower Coal Measures, Quinnimont. Other numbers as in Fig. 1.

FIG. VI.—Clinch fault on Osborn Ford road. *f*, Fault. Numbers as before.

FIG. VII.—Structure on Robinson fork of Lewis creek, after Squiers. *xy*, line of New Garden fault. *a*, Lower Coal measures (Quinnimont). *E*, Lower Carboniferous. *b*, Knox beds.

Clinch Mountain group of folds is of no little interest as having some bearing on the relative age of the folds and faults. The anticlinal originates probably at but a little way from Little Moccasin creek, and as it increases steadily eastward, it thrusts the outcrops of the successive groups further and further toward the south-south-east. On Wolf run, along the railroad grade, the whole of the Lower Carboniferous column is exposed, the red shales being well shown in the long cut at the summit. These rocks describe a synclinal and anticlinal which are distinct on Wolf run. On this railroad line, then, the Knox beds are in contact with the very top of the Lower Carboniferous. Eastward the red shales are cut off more and more in the fault, so that at Saltville only a small part remains exposed, and the fault passes very near the crest of the anticlinal seen on Wolf run. At ten miles east from Saltville, the greater part of the limestones have been swallowed up, while on I. H. Buchanan's property, sixteen miles from Saltville, there remain merely the clayey limestones and the shales at the base of the series; and at the line of Bland county all has disappeared save the coal-bearing shales.

So this fault, in crossing the strike of the rocks, carries down in succession the several divisions of the Lower Carboniferous. Its course can be followed by the eye without difficulty, for the ragged hills of Knox sandstones and limestones, near whose northerly foot it passes, go directly to Garden mountain, the southerly slope of the Burk's Garden anticlinal. It is wholly probable that, beyond the eastern border of Smyth county, the Lower Carboniferous disappears, so as to bring the Chemung and Knox into contact; while still further east the Lower Carboniferous may re-appear as the anticlinal loses strength.

What erosive effects have been due to the influence of the fault cannot hardly be ascertained. Unquestionably there is what is termed a valley in the vicinity of the fault for much of the distance within Washington and Smyth counties—but it is in the vicinity only; such a valley can be found in the vicinity of almost any other line which one may choose to draw within the limestone region. Rich valley, now on one side, now on the other side of the fault in Washington county, is merely a succession of cross-valleys separated by irregular divides; but in Smyth county it is altogether south from the fault, except near Saltville, and is separated from it by the rugged ridge of Knox beds.

The Clinch Mountain Series of Folds.

This series enters the State from Tennessee at ten or twelve miles west from the line of Washington county, and extends thence in an E.N.E. direction through Scott, Washington, Smyth and Bland counties into Giles. Clinch mountain is the bold ridge at the north with a Medina cliff for its crest, with Clinton for its southerly slope and with Hudson and Trenton forming the northerly slope; a Poor valley of Clinton and Hamilton separates it from Brushy mountain, a clumsy mass near the State line, but owing to encroachments by the Saltville fault becoming simpler

and better marked until it is a single ridge with a cliff of Chemung sandstone for its crest.

In a section extending from Moccasin creek to the Saltville fault at Wolf Run summit this series shows monoclinal structure from Moccasin creek until within about two miles of the summit, where one crosses the petty folds already mentioned. At not far from twelve miles further east, near Little Moccasin creek, a new feature is introduced and the Poor valley is divided by a gentle anticlinal, the structure being as represented in Fig. 1. This anticlinal may be the same with that which is designated the Burk's Garden anticlinal, or it may be a petty fold dying out on the Tazewell pike in the synclinal north from that anticlinal. The development of the anticlinal and the accompanying synclinal on the northerly side pushes the Clinch outcrop of Medina northward so as to form the irregular Brumley mountain, which at ten or twelve miles further eastward is cut off by the growing Loop anticlinal. The Clinton shales held up by the new anticlinal, widen Poor valley into Brumley and Hayter coves extending from Little Moccasin creek eastward almost to Tumbling creek, somewhat more than fifteen miles in a direct line.

A projection somewhat like Brumley mountain, but better defined, is shown further east beyond the Cedar Creek loop or cove, the first of the coves or anticlinal valleys with Medina rim. Brumley mountain forms the south-westerly boundary, Little Bear town the easterly and northerly, while the notched border of Clinch mountain forms the southerly and south-easterly border. The cove is not wholly enclosed, as the Medina has been removed from the north and north-west for probably five miles. The structure along a section beginning at the Fincastle pike and passing through Hayter's gap in Clinch mountain to the Saltville fault is shown in Fig. 2. The Loop anticlinal is crossed by the road to Hayter's gap just north from the Rich Mountain road. It is complex and apparently attains its maximum further west, where it cuts off the Medina of Brumley moun tain. It diminishes quickly eastward so that the Medina outcrops of both Clinch and Little Bear town unite at the head of the cove or loop. The Burk's Garden anticlinal in Poor valley attains to no material elevation along this line, and is simply a broad roll, which serves to carry the outcrop lines of Devonian and Lower Carboniferous southward, as is well shown at Saltville, where nearly the whole of the Lower Carboniferous red shales have disappeared in the fault, which there passes very near the crest of the Wolf Run anticlinal.

The next section, that passing from Liberty on the Fincastle pike to the Saltville fault about nine miles west from Saltville, is shown approximately in Fig. 3. The Thompson-Ward cove, also on the northerly side of Clinch mountain, is crossed by the Tazewell pike along the line of this section. It is not far from twenty miles long and is enclosed on all sides by Medina, save on the north-west, where there is a gap of nearly six miles. The westerly end is known as Ward's cove, enclosed by Short mountain on the north-west and on the south by Clinch mountain, which is continuous

along the southerly side of the whole cove. The east end, known as Thompson's cove, has Clinch mountain as its southerly boundary and Rich mountain as the northerly. This is a typical cove; the Medina outcrops approach very gradually at each end so as to give a distinctly lozenge-shape to the outline. The Medina has been removed by erosion for a distance of fully six miles, the distance between Short mountain and Morris knob, the latter being the end of Rich mountain; while Plum creek has made a water gap through Rich mountain almost due south from Jeffersonville, the county seat of Tazewell county. There evidently the whole of the Medina has been removed for a distance of nearly three miles—but the ridge is persistent on both sides nearly to the gap. The Cove anticlinal is not the same with the Loop anticlinal; as the latter diminishes, the former, lying somewhat further north, increases.

The synclinal between the Cove and the Burk's Garden anticlinal is very close and complex along the Tazewell pike; the dips are abrupt, and three subordinate folds were seen in the Clinton, between Clinch and Flat Top mountains. The pike crosses Clinch mountain at but a little way west from the maximum of the Cove anticlinal, crosses the northerly division of the Poor valley, and ascends the Burk's Garden fold which, within six miles, has brought up Medina through the Clinton to form a bold ridge, known as Flat Top or Poor Valley mountain. The Saltville fault is reached beyond Brushy mountain, but the exposures do not suffice for determining how much of the Lower Carboniferous has been cut off.

From this line eastward, the structure of the belt between the Elk Garden anticlinal at the north and the Saltville fault at the south becomes simpler. As the Cove anticlinal diminishes, the synclinals on each side gradually approach until they unite in the valley of Wolf creek, between Rich mountain and Garden mountain. The Medina outcrop of Clinch mountain passes round the easterly end of the Thompson-Ward cove, and forms the crest of Rich mountain eastward from Plum creek, while the Clinton of the northerly Poor valley is continuous with that of the Wolf Creek valley. That the Cove anticlinal wholly disappears before the road leading from Jeffersonville to Burk's Garden is reached is not altogether certain. In descending the southerly slope of Rich mountain along that road, one leaves the Medina at the summit, and quickly comes upon exposures of the Clinton, the dip being almost east of south; but the dip is reversed soon, and the synclinal is close. Exposures in the Wolf Creek valley are not detailed, but the presence of a very gentle anticlinal explains the greatly diminished dip shown an the slope of Garden mountain. The rapid increase of the Burk's Garden axis is shown by the clumsy mass known as Bear town, from which the Medina walls of the Garden pass out. These walls unite at the east end of the Garden to form Round mountain, and thence the fold diminishes. Prof. W. B. Rogers, in one of his memoirs, speaks of this as the "great Garden anticlinal." Burk's Garden has an extreme length of about six miles, and an extreme width of not far from four miles. The surrounding wall is broken only at the

gap of Wolf creek at the north, by which the road from Jeffersonville enters. The immediately underlying rocks of the enclosure are Trenton, while Hudson and Medina are shown in the Garden mountain.

The Copper Creek Fault and the Elk Garden Anticlinal.

The Copper Creek fault of the writer's previous memoir was observed in Russell county on the Abingdon and Wise Court-House pike, at a little way from the summit between Tarr's fork of Moccasin creek and a petty branch of Copper creek. The fault is clear because of repetition of the section, and its place is indicated by abrupt steepening of the dip. The line was not followed eastward from that locality, but the fault certainly disappears before Little Cedar creek has been reached, ten miles further east, for there it is represented by two close anticlinals, or by an anticlinal with channeled crest. In the Elk Garden, three miles east from Lebanon, this anticlinal is crossed by the Fincastle pike, near Mrs. Smith's house, where it brings up the ferriferous beds at the top of the Knox group; it is distinct as a triple-crested fold passing just south from Liberty in Tazewell county. It passes near Jeffersonville in the same county, and is crossed by the pike at the school-house, about four miles east from Jeffersonville. The course of this axis varies somewhat under the influence of the Loop and Cove anticlinals, so that beyond Jeffersonville it is little more than north of east. This fold is interesting only in that it illustrates the disappearance of a fault in an anticlinal. The Trenton and Knox alone cross it, all newer beds having been removed by erosion.

The House and Barn Synclinal.

This trough lies directly northward from the Elk Garden anticlinal, and appears to be practically co-extensive with it. Some indefinite flexures of Trenton and Knox beds were seen in Scott county, very near the line which this synclinal, if continuous, would follow; but the first real trace is found in Russell county, between the Wise Court-House road and Old Russell court-house, on the way to Osborn's ford. It is thoroughly distinct at six miles further eastward, where the Mill creek and Abingdon roads unite at Little Cedar creek, about two miles west from Lebanon, where it holds the upper or clayey limestones of the Trenton. It passes immediately north from Lebanon, and is distinct on Little Cedar creek, near the road leading to Nash's ford. At both localities it is shallow and double, but its rapid deepening eastward is shown on the road leading from Black's ford to Rosedale; while immediately east from that road it holds a narrow ridge, House and Barn mountain, which carries a slender crest of Medina. This mountain, lying at about a mile and a half north from the Fincastle pike, is cut off by the Maiden Fork of Clinch river; but, within two miles beyond that stream, the Medina ridge again begins, now under the name of Paint Lick mountain, and continues for nearly twelve miles, when it is cut off by Plum creek, a tributary to Clinch river. Paint Lick is no doubt a double synclinal even at its western extremity, but this was not

determined by actual examination. Be that as it may, the mountain is quickly divided into two very narrow synclinals, separated by a narrow, compressed anticlinal, along which a valley has been eroded to the Trenton. The ridge in the southerly synclinal retains the name Paint Lick, while the short irregular ridge in the other trough is known as Deskins mountain, and continues for but three or four miles.

Erosion has been performed so faithfully beyond Plum creek that, for a distance of fully eight miles, all rocks newer than Trenton have been removed from the synclinal; but, at say four miles east from Jeffersonville, the Medina ridge is reached again in East River mountain, which clearly represents Paint Lick. It, however, is distinctly double, two synclinals separated by a narrow anticlinal, which evidently widens eastward, so that the synclinal mountains are wholly separate and bear distinct names. Deskins mountain appears to be represented by Dial mountain, an irregular little mountain with Medina crest. No examinations were made east from the Dial or north from East River mountain, so that the coloring of that portion of the map is not exact

Within Tazewell and eastern Russell, the rocks rise regularly or nearly so from the synclinal to the New Garden fault, the rate of dip increasing toward the fault; but westward, as the synclinal becomes less pronounced, the rocks become distorted at a distance of two or three miles from the line of fracture. A synclinal occurs on the high limestone ridge, known as Copper ridge, within Scott county, but it disappears before reaching Mill creek in Russell county, for there no traces of it were found. Even where this indefinite synclinal exists, the rocks are badly twisted at varying distances from the line of displacement. Thus, on the road to Osborn's ford, the distortion begins at some distance above Barlow Nickels' house, or more than two miles south from the fault; on the road, one mile east from Lick creek of Clinch river, sharp folding was seen at a mile or more south, and it evidently continues almost to the fault; further east, the greatest complications are in the shales near the river, while disturbance appears to be wholly wanting near the line of fault; still further east on Lewis creek, near the mouth of Indian creek, and on Cavitts creek, the disturbance is insignificant, and the dip is regular for the whole distance.

The Clinch River System of Faults.

The general name here employed is that applied by Prof. Lesley to two members of the system, and it includes the Hunter Valley fault of the writer's previous memoir. No name less open to objection can be proposed; but this should not be taken as implying anything more than that in a general way the faults and the river are nowhere separated by an interval of more than a few miles.

Clinch river rises in eastern Tazewell, and flows thence through Russell and Scott into Tennessee; the distance within Virginia is, in direct line, not far from ninety miles, but by the river channel is probably one hundred and thirty or one hundred and forty miles. At about twenty miles

from its source, the stream first reaches the line of fault, near which it lies for about six miles, crossing it more than once in that interval. This is between the mouth of Indian creek and the western line of Tazewell county. At, say, twenty-five miles further west, measured directly, the river again reaches the fault, and, within the next seven or eight miles, crosses and recrosses the line more than once, if the map may be trusted. Above the former space, the interval between river and fault gradually increases to not far from six miles with the mountains of the House and Barn synclinal in it. Between the two contact spaces, the river channelway is bow-shaped, the interval increasing rapidly to six miles on Lewis creek, and thence diminishing slowly until it disappears below Lick creek. Below the second contact-space, the interval steadily increases, and at length the river flows very near the line of the Copper Creek fault.

The Clinch Fault.

The course of the Clinch fault in Scott county is shown approximately by Buckner's ridge, composed of Knox beds, except near the line of Russell county, where it is made up of Quinnimont beds. The fault enters Russell county very near the mouth of Guest's river; is crossed at the mouth of Russell creek (Squier); is cut by Clinch river both above and below the mouth of Whetstone creek; and by Lick creek at but a little way from the river. At this last locality, the course changed somewhat to the northward, so that the fault is crossed by Caney fork of Dump creek very near Abram Kiser's house, and by Dump creek very near the mouth of Hurricane fork. Beyond this stream it was not followed. It should be found passing through the loop of Buchanan county at not more than four miles north from the southernmost projection of Big Butt mountain, on whose southerly slope Robinson fork of Lewis creek has its sources.

Thus far the structure has been comparatively simple and the direction of the fault-line almost straight—at least, its deviations can hardly be shown on a map of ordinary scale. Where first observed by the writer, on the north fork of Clinch river, in southern Scott county, the relations are apparently as shown in Fig. 4; but, within a very little way, where the road crosses Buckner's ridge, there is no upturning at the fault, the Lower Helderberg, Oriskany and Hamilton continuing to the very line of fault without change of dip. But still further eastward, the Pattonsville and Wallen Valley faults having died out, and the Stone Mountain anticlinal having become fully developed, the reversal of dip is shown again, so that the Hamilton, Lower Carboniferous and Quinnimont are crossed in succession as one goes north-westward from the line of fault. On Stony creek, also in Scott county, the same condition is shown even more clearly, for there the Knox beds have been removed by erosion for some distance, so as to expose the Silurian beds, as represented in Fig. 5. Thus far the ridge marking the course of the fault is Knox, but on the road leading from Osborn's ford to Guest station, the "hanging rock" is Quinnimont.

Exposures are wanting for some distance below this Quinnimont wall on Little Stony creek, but the place of the rock in its group seems to indicate that here the Knox and the Quinnimont are in contact, as in Fig. 6. No Quinnimont occurs east from the mouth of Russell creek, and thence to the Caney fork of Dump creek, the Middle Coal measures (Lower Coal measures of Pennsylvania) are in contact with the Knox group.

The New Garden Fault.

But at or very near Bee branch of Caney fork of Dump creek, a cross-fault is given off, which extends in a south-west direction for about three miles. At that distance, it unites with the New Garden fault, which first shows itself at not far from three miles below the mouth of Dump creek, and follows very nearly the line which would have been followed by the Clinch fault had not its course been changed at Lick creek. The cross-fault gives a wedge-shape to the Knox area, the point being at Bee branch of Caney fork, and brings that group into contact with Hamilton and very probably with Clinton (?) shales. The New Garden fault is crossed by Dump creek, at barely a mile from the river, and there the Lower Carboniferous limestone is brought into contact with shales, much contorted and belonging probably to the Knox group.

No examinations were made along the immediate line of fault between Dump and Lewis creeks, though the southerly side was followed somewhat closely for several miles. A very great change takes place in this interval. On Dump creek, Middle Coal measures on the north side and Devonian or Silurian on the south side of the Clinch fault are in contact; but the downthrow between the faults increases so that before reaching Big Butt mountain, the Middle Coal measures on the north side of Clinch fault are in contact with Lower Coal measures (Quinnimont) on the southerly side; while, according to Mr. Squiers, an anticlinal has developed along the northerly side of the New Garden fault so as to bring the Lower Carboniferous limestone into contact with the Knox. The writer's examinations were not made in sufficient detail along Lewis creek to decide respecting the exact relation of the limestone and coal, but the strip of Lower Carboniferous must be very narrow. Mr. Squiers' diagram as given in *Science*, No. 68, is reproduced in Fig. 7.

The New Garden fault continues evidently in the direct line, being crossed by Clinch river in the bend opposite mouth of Indian creek; passing south from the Baptist Valley road and thence for four miles to Low's fork of Indian, where the road turns into the valley; crossed by Cavitt's creek near the forks in Wright's valley, and, according to Prof. Lesley, by the Jeffersonville and Abb's Valley road near Capt. Frank Peery's house, six miles from Jeffersonville. As shown from mouth of Indian to Cavitt's creek, this fault brings the top of the Lower Carboniferous into contact with the Knox. The dip of the Lower Carboniferous shales is usually abrupt and no upturning was observed near the line of faulting. The downthrow evidently increases eastward, for on Cavitt's creek the very

top of the Lower Carboniferous is shown and Prof. Lesley states that a coal bed is shown near Capt. Peery's house on the Abb's Valley road.

The Stony Ridge Fault.

A new member of this series, the Stony Ridge fault, has its origin somewhere between Lewis creek and the line of Tazewell county; but, as the interval between Lewis and Middle creeks, about ten miles, was not examined, the place of its origin was not ascertained. In all probability, however, the anticlinal on Lewis creek marks the beginning of this fracture. The downthrow on the northerly side brings into contact with the Devonian and Silurian the Lower Coal measures (Quinnimont), which form the Big Stony ridge separating Abb's valley and Crockett's cove from Wright's valley. If one descend Low's fork of Indian from the New Garden fault, he crosses the Lower Carboniferous shales and limestones and reaches the Devonian before coming to the Lower Coal measures on Laurel fork of Indian. On Dry fork of Sandy, the whole of the Lower Carboniferous, the Devonian and possibly the upper beds of the Silurian are passed before one comes to the Lower Coal measures (Quinnimont) beyond this fault, which is crossed by the stream at barely one mile above the mouth of Dick's creek; while on the road leading to Crockett's cove, the other side of Stony ridge is reached, the Lower Carboniferous is shown at three miles from the mouth of Dick's creek and the road soon descends into Crockett's cove, which is separated from Abb's valley by a narrow divide. The Stony Ridge fault is crossed by Cavitt's creek, where Silurian is present, and it must be found at the West Virginia line, since the Big Stony ridge is said to be continuous to that line.

The Abb's Valley Fault.

Near the old Scott mines on Middle creek, an anticlinal occurs, which Prof. Lesley has suggested may mark the origin of a new fault which he has named the Abb's Valley fault. There is every reason to suppose this true. The fault develops eastward slowly until near the Dry fork of Sandy, where the upthrow becomes very marked, bringing the Lower Carboniferous and Devonian to the surface in Crockett's cove. The fault passes at but a little way north from the forks of the road in that cove. The downthrow on the northerly side diminishes eastward, for along Laurel fork and other tributaries to Bluestone river, a thickness of from 500 to 900 feet of Lower Carboniferous shales was seen between the river and the Lower Coal measures (Quinnimont). The length of the exposed column of Lower Carboniferous increases eastward in West Virginia to the New River.

The Stone Mountain Anticlinal.

The structure of this fold makes it necessary to study it from the east westward.

The Stone Mountain anticlinal was observed first on Russell creek in Wise county; the place of its axis is concealed on Bull creek as well as

on the tributary to Guest's river crossed by the Wheeler Ford road; but it is crossed by the Osborn's ford and Guest's Station road at little more than a mile from Guest's river; further westward it passes between High Knob and Little Stone gap. The anticlinal can be traced thence to the Tennessee line, the axis lying close to Stone or Cumberland mountain.

The fold is utterly insignificant on Russell and Bull creeks, but becomes well-marked on Guest's river. It is crossed by the Middle Coal measures on the former streams, but the Lower Coal measures are brought up in the gorge of Guest's river. Thence westward, the increase in strength is rapid and the Lower Coal measures are raised quickly to form the Powell-Stone mountain lying between Buckner's ridge and the valley of Butcher's or South fork of Powell river. The dip on the southerly side is gentle throughout, but soon becomes abrupt on the northerly side—at Guest's river it is from 5 to 7 degrees, but at Little Stone gap the rocks are almost vertical and so remain to beyond Pennington's gap in Lee county.

Three well-defined faults, described in the writer's previous memoir as the Pattonsville, Wallens Valley and Poor Valley, develop on the southerly side of this fold and cut off abruptly the clumsy Powell-Stone mountain. The Carboniferous rocks have a curved outcrop at the westerly end of that mountain, while in Powell mountain beyond North fork of Clinch river, in Wallens ridge and in the broad valley of Powell river, the Devonian, Silurian and Cambro-Silurian are exhibited. From Big Stone gap in Wise county the area affected by the fold embraces only the precipitous Stone mountain and a very narrow space directly adjoining it on the southeast. The fold from Little Stone gap to the State line is so abrupt as to resemble a fault; its trend is at an acute angle with the lines of faulting.

Vertical Extent of the Faults.

The following table shows approximately the vertical extent of the several faults—the extremes only being given.

Clinch	8500 to 1000
New Garden	7500 to 6600
Stony ridge	2300 to ??
Abb's valley	1700 to ??
Saltville	10000 to 7000
Walker mountain	7500 to 3000

II. THE GEOLOGICAL GROUPS.

Benches and terraces, beautifully preserved, were seen at many places, but the time allotted to this reconnaissance left few opportunities for making measurements of altitudes. Clinch river is bordered for the most part by high hills, so that in order to secure available grades, wagon roads usually follow the gorges of tributary streams. For this reason, the existence of terraces is concealed from the traveler until the river is reached. But where, as in a few cases, the road descends directly from

the bordering ridge, avoiding the stream, the presence of terraces is distinct. The higher benches, which apparently have no relation to the river terraces, are equally distinct. Only one measurement of a higher bench was made.

A few measurements of river terraces were made on Clinch, which are approximately correct.* In descending Copper ridge, in Scott county, to Osborn's ford, a bench was seen, 640 feet above low water, at Morton L. Harris' house, somewhat more than a mile from the river. It carries a detrital deposit, containing small waterworn pebbles of quartz and other materials, none of them larger than a hen's egg. No other terrace or gravel deposit was seen along the road on this side of the river until the "bottom," fifteen feet above low water, was reached, as the road follows an irregular ravine; but a terrace was seen on the northerly side of the river at eighty feet above the "bottom," on which is a thick deposit of clay, sand and gravel, with many large bowlders of Coal Measure conglomerate. This terrace is conspicuous on the opposite side of the river at a little way above the ford, where there is an intermediate terrace, whose altitude was not ascertained. In descending Copper ridge to Nash's ford, almost due north from Lebanon in Russell county, river terraces were observed at 155, 40 and 15 feet above low water at the ford, and the highest one extends a long way southward from the river. Each bench bears a thick deposit of detrital matter with great quantities of bowlders. What the condition is on the north side of the river was not determined, as the road follows a deep ravine for several miles.

The only satisfactory measurement obtained along the North fork of Holston was near Laurel fork, seven miles east from Saltville. The deposit is from 85 to 90 feet above low water and contains bowlders of large size in sand and clay. The river road follows for nearly a mile. Well-marked terraces were observed along this river at many places, but no good measurements were obtained.

Sufficient evidence has been secured by measurement and observation to prove that the streams in this region are as handsomely terraced as are those of Western Pennsylvania and the adjoining parts of Maryland and West Virginia, both east and west from the Allegheny mountains; and the writer's observations in the Flat Top region of Tazewell county and the adjacent part of West Virginia satisfy him that the geologist who enters this region with time to make detailed observations, will find the higher system of parallel benches as beautifully preserved as they are in the areas of Maryland, West Virginia and Pennsylvania, described by the writer.† It is very interesting to note that these higher benches are well preserved only in softer rocks, the shales and sandstones of the Devonian and Car-

*The writer's barometer became deranged early in the examination and was useless; so that the trustworthy measurements are few.

†Stevenson. Surface Geology of Southwest Pennsylvania and Adjacent Portions of West Virginia and Maryland. Read before Amer. Phil. Soc., Aug. 15, 1879.

boniferous, as though the agency to which they owe their origin had not been long at work.

The only deposit of Quaternary age, aside from the terrace deposits, is that near Saltville, in Smyth county, where a conglomerate overlies the great mass of gypsum. This material has been exposed by a railroad cut west from Saltville, where it is said to have yielded remains of *Mastodon*. It is a conglomerate of red and blue clay, sandstone and large, mostly waterworn blocks of Knox chert and calcareous sandstone, the cement being mostly selenite. A small part only of the original mass remains, by far the greater part having been removed by erosion. No deposit of similar character was seen at any other of the gypsum bearing localities.

The deposits of gypsum and common salt occurring at Saltville and other localities on the North fork of Holston river, belong in all probability to the Tertiary. Their character and relations will be considered in another part of this memoir.

The Coal Measures.

It is unfortunate for the nomenclature of the Carboniferous that the rocks of that age were first studied and classified in Pennsylvania. Had the study and classification been made in Virginia, the nomenclature would have been different and would have been better applicable to the several areas in which Carboniferous rocks occur. The Coal measures begin with the Seral or Pottsville Conglomerate of Pennsylvania; which in that State is for the most part of little economical importance, but in Virginia and much of West Virginia is equally important with the overlaying beds, the Lower Coal measures of the accepted nomenclature. The proper terms fitted for the whole of the Appalachian area are:

Upper Coal Measures, equivalent to the Upper Coal measures of Pennsylvania, Ohio and West Virginia, begining with the Pittsburgh coal bed and continuing to the top of the series;

The Middle Coal measures, equivalent to the Lower Coal measures of the States already mentioned; and

The Lower Coal measures, equivalent to the Seral or Pottsville conglomerate of Pennsylvania, the Millstone grit of Ohio and the Quinnimont group of Virginia and West Virginia. It attains great thickness in the Virginias, where it contains the coking coals of the New river and its tributaries.

The Coal measures do not cross to the south of the Clinch system of faults though they are entangled among them. The Middle and Lower groups only are reached in the area examined.

The Middle Coal measures occur within Wise and Russell counties as far east as the line of Buchanan county. They are cut off by the Clinch fault which passes into Buchanan county between Dump and Lewis creeks, so that in that county the Middle and Lower Coal measures should be found faulted against each other north from the latter creek. The more

important coal beds described in the writer's sections * made on the headwaters of Powell river in Wise county are persistent and have been recognized as far east as Dump creek. The associated rocks show the same characteristics as on the headwaters of Powell river. Limestone appears to be absent and one of the sandstones is coarsely conglomerate.

The Lower Coal measures form the mass of Powell-Stone mountain under the Stone Mountain anticlinal in Scott county, but they quickly pass under the Middle Coal measures, owing to the rapid disappearance of that axis eastward. No exposure appears on the northerly side of the Clinch fault beyond Russell creek eastward. But the beds reappear on the southerly or upthrow side of that fault beyond Weaver creek in Russell county; as well as on the downthrow side of the Stony Ridge and Abb's Valley faults in Tazewell county. The important mines at Pocahontas on Laurel fork of Bluestone river in eastern Tazewell are in a bed belonging to this group. Scott's mines on Middle creek, Christian's mines on Laurel fork of Indian and Sayers' old mine on Dry fork of Sandy, all in Stony ridge, are in beds belonging to the Lower Coal measures. No rocks belonging to the higher group occur in Tazewell county or in Russell county east from Lewis creek. The full thickness of this group is not exposed within the area examined and the higher beds must be sought for in Buchanan county of Virginia and McDowell county of West Virginia. The passage to the Lower Carboniferous is gradual.

The Lower Carboniferous.

Lower Carboniferous rocks occur in irregular strips along the fault lines. The most important is that on the northerly or downthrow side of the Saltville fault, which tapers in width from nearly five miles on the Tennessee line to almost nothing at the easterly boundary of Smyth county. The whole section is shown best in this strip. A narrow strip extends for a little way on both sides of Dump creek along the New Garden fault and another, also on the downthrow side of the same fault, begins near Lewis creek and continues eastward certainly beyond Cavitt's creek. A third strip is shown on the upthrow side of the Abb's Valley fault in Crockett's cove and Abb's valley, while a fourth develops on the downthrow side of the same fault along the waters of Bluestone river.

The section of the Lower Carboniferous as shown in Washington county was given in the previous memoir. There Prof. Safford's classification was accepted as follows:

Mountain limestone.....	1. Red shales, sandstones and thin limestones; 2. Limestones and calcareous shales.
Silicious group.....	1. Cherty limestone; 2. Protean group.

*Stevenson. Notes on the Geology of Wise, Lee and Scott counties, Virginia. Read before Amer. Phil. Soc., Aug. 20, 1880.

The Protean group of Safford is practically equivalent to the Vespertine of Southern Pennsylvania and the latter name will be employed as more convenient. The group is represented by shales, sandstone and thin *coal beds*, with occasional impure limestones.

The best general section of the Lower Carboniferous is that obtained along the railroad grade from Wolf Run summit to the North fork of Holston near Mendota. This section has been given in the writer's "Reconnaissance;" but on that line the Vespertine is wholly concealed and at best is reduced to utter insignificance. The beds previously referred by the writer to the Vespertine prove to belong to the Chemung. The thickness of the Vespertine increases eastward, so that at Laurel fork, about seven miles east from Saltville, it is not far from five hundred feet. This group is divided almost midway by a white or grayish-white sandstone which, for a long distance, forms a low but well marked ridge along the southerly face of Brushy mountain. Some beds of very impure limestone occur in the upper shales and the passage to the more calcareous division through silicious limestones and hard calcareous shales is very gradual. *Coal beds* occur in this group at many localities between Little Moccasin creek and the eastern edge of Smyth county, but they have no economical importance.

The Vespertine is apparently of insignificant thickness among the Clinch faults. Its place is shown on Dump creek near the New Garden fault; on Indian creek between that and the Stony Ridge fault; in Crockett's cove near the Abb's Valley fault and on several other streams; but at all of these localities the group is practically wanting or has become more calcareous, so as to be merged into the middle division—a condition which, according to Prof. Safford, prevails in Northeastern Tennessee. But the whole of the Lower Carboniferous column is greatly diminished among the Clinch faults within the area examined, just as was observed in comparing the region about the headwaters of Powell river with that along the North fork of the Holston.

The limestones and upper shales are often richly fossiliferous. The collector cannot fail to get good returns on Wolf run and the North fork of Holston in Washington county; along a road following the same river for several miles below Saltville; and on Low's fork of Indian creek in Tazewell county.

The Devonian.

This age is represented by Chemung and Hamilton; the Catskill and Corniferous appear to be wholly wanting.

The Chemung is represented by sandstones varying in color from light gray to brown, the color becoming darker in the upper beds. It forms the crest of Brushy mountain and is fairly well exposed in many of the ravines cut through that mountain. A section was obtained on the rail-

road grade near Mendota in Washington county, which, condensed, is as follows:

Chemung.

1. Shales and sandstones, shales gray to reddish blue, sandstones gray and flaggy	33′	
2. Sandstone, above brownish-blue, hard, irregular fracture, flaggy with nodules of clay; below irregularly flaggy, clayey, micaceous, with large fucoids	31′	
3. Conglomerate	0′	4″
4. Sandstone, brownish, fossiliferous, with *Spirifera, Rhynchonella, Chonetes, Goniophora, Edmondia,* etc	11′	8″
5. Conglomerate, ferruginous, pebbles as large as chestnuts	0′	10″
6. Sandstone with some fossils	5′	
7. Conglomerate	0′	6″
8. Sandstones, not wholly exposed, with *Spirophyton* and *Productella* in the lower portion	268′	
	350′	

The upper part becomes harder and thicker further eastward. Whether or not the conglomerates are persistent was not determined, but no fragments of them were seen at any locality beyond Little Moccasin creek; nor were any traces seen on Little Walker mountain along the road leading from Lyons gap to Chilhowie Springs.

The Chemung appears to be wholly absent along Stone mountain in Lee and Wise counties and no trace of it was found along Buckner's ridge in Scott county between the Hamilton black shale and the Lower Carboniferous limestones. But the group is present further east among the Clinch faults, for it was recognized on Indian creek at the mouth of Laurel fork, on Dry fork of Sandy and in Crockett's cove.

The Hamilton consists almost wholly of shales, is ill-exposed everywhere and no satisfactory line of separation could be found between it and the Clinton below. It was measured near Mendota, where the total thickness appears to be not far from 900 feet. The relations of these shales to the group in more northern localities could not be determined as the few fossils observed were so imperfect as not to be identifiable. The greater part of the shales, however, appears to represent the Marcellus epoch and the black shales alone remain under the Stone mountain anticlinal in Lee and Wise counties.

The Hamilton is shown on the northerly side of Little Walker and Brushy mountains; without doubt it is present on Eagle Nest and Dump creeks in Russell county as well as on Dry fork of Sandy and on Cavitt's creek in Tazewell county, but no separation from Clinton was attempted on any of those streams.

The Silurian or Upper Silurian.

Clinton and Medina alone represent this age within the area examined. In Scott, Lee and Wise counties the Oriskany and Lower Helderberg are exposed repeatedly by faults there developed on the easterly side of the Stone Mountain anticlinal. Those groups were recognized even under the Clinch fault on Stony creek in Scott county; but they evidently thin out somewhere between the Clinch fault and Clinch mountain and their disappearance eastward is equally well-marked. There is no reason to suspect a fault between Clinch mountain and Brushy mountain; on the contrary, the succession of Clinton, Hamilton and Chemung is shown on the bluff northerly side of Brushy mountain at nearly two miles east from Laurel Fork gap; many petty gaps show conformability throughout and that the Clinton passes gradually into the Hamilton. The same conditions are shown in passing from Big to Little Walker mountain. Beyond doubt, the Clinton is reached on Dump creek, Dry fork of Sandy and Cavitt's creek, but no Oriskany was observed on any of those streams, nor was anything seen which could be referred to the Lower Helderberg, except possibly a limestone found on Dry fork of Sandy at half a mile above the Stony Ridge fault. The disappearance of these groups in a south-eastward direction is in great contrast with the great thickening of the Lower Carboniferous and Devonian in the same direction.

The *Clinton* forms a bench on the southerly slope of Big Walker and Clinch mountain sand is the surface rock in much of the Poor valley following the foot of each mountain. Narrow strips occur along the crests of Paint Lick, East River, Dial, Deskins and possibly of House and Barn mountain. The group consists of variegated shales with the whitish sandstones which everywhere lie near the fossil ore and are characteristic of the group through its extent. The fossil or "dyestone" ore is present on all the mountain mentioned. Limestone appears to be wholly absent. The thickness of the group was not ascertained, but it cannot be less than 1000 feet.

The *Medina* forms the crest of Big Walker montain; of Clinch mountain, and its outliers, Rich, Garden, Short, Little Bear Town and Brumley; of House and Barn mountain; and it makes a double outcrop near the summit of Paint Lick and East River mountains.

The upper or white Medina, in irregular layers and from 200 to 300 feet thick, forms jagged cliffs. It contains a few thin layers of conglomerate, but, for the most part, the rock is very far from being coarse and some of the upper layers weather with polished surface. No fossils were seen aside from the characteristic *Arthrophycus harlani*.

The lower Medina, a mass of red to reddish-brown sandstone and shale, forms a terrace on the sides of the Medina ridges. It does not differ from the beds recognized as lower Medina in the central tier of counties in Pennsylvania, where it is sometimes called the terrace formation. The thickness is not far from 400 feet; but at all exposures the group is so badly

contorted that the true thickness can be ascertained only after detailed examination. This part of the Medina is very closely allied to the Cambro-Silurian. It contains *Ambonychia radiata* and *Rhynchonella capax* in Southern Pennsylvania; it contains the same forms, with others equally characteristic of the Hudson, in Southwest Virginia. These fossils can be collected in Lyons gap on the northerly side of Big Walker mountain in Smyth county and in Hayter's gap on the north side of Clinch mountain in Russell county. In each case the exposure is conspicuous, being at the roadside and well known to the people living in the neighborhood.

The Cambro-Silurian or Lower Silurian.

This is represented by Hudson, Trenton and Knox or Calciferous, the Utica being absent or so changed that it cannot be separated from the Hudson or Trenton. Rocks of the Trenton and Knox are the surface beds in the Great valley as well as in the broad area between Clinch mountain and the Clinch series of faults. Hudson beds occur at the northerly foot of Big Walker and Clinch mountains and outcrop around the synclinal mountains with Medina crest, which are seen in Tazewell county northward from Clinch mountain.

The Hudson consists of red to yellow sandy shales and the passage to lower Medina is wholly imperceptible. The yellow shales below become calcareous and the passage to the Trenton is equally gradual. The upper beds of the latter group are very argillaceous, but the limestones become much purer lower down in the column, until the marbles are reached near the bottom of the group. These are thoroughly characteristic. Toward the bottom of the marbles some massive limestones occur containing much black chert; these mark the passage to the silicious Knox group in which are several beds of white chert and many thick beds of very hard and slightly calcareous sandstones. This is merely the Calciferous of New York, vastly increased in thickness.

No detailed section of any portion of the Cambro-Silurian was attempted, but enough was observed to show that the writer's estimate of 3250 feet for the thickness of the Knox group is materially below the truth.

III. THE AREA DRAINED BY THE HOLSTON RIVER.

In going from Bristol northward toward Mendota, one rides on Trenton and Knox beds until the Saltville fault is reached at a little way beyond the Rich Valley road. The Walker Mountain fault is crossed at about four miles north from Bristol, not far from the Reedy Creek road. The red, more or less calcareous shales, forming the top of the Lower Carboniferous and dipping sharply toward the south-south-east, are exposed in the railroad cut at Wolf Run summit just beyond the Saltville fault. A well-marked anticlinal is shown on Wolf run at a few rods above the school-house; the place of the synclinal was not determined, as exposures are somewhat indefinite below Whetstone run, but long before the river has been reached

the dip is again south-eastward and so continues apparently to the crest of Clinch mountain.

Lower Carboniferous limestones, of which the section was given in a previous memoir, are well shown along the run and the railroad grade beyond the river crossings, but the lower or Vespertine portion is wholly concealed. A detailed section of the Devonian beds, as shown along the railroad, is as follows, the top being at the northerly side of the little valley opening from the east.

Chemung.

1.	Shales, alternating beds of gray and reddish-blue; sandy; the gray beds hold thin flaggy sandstone; the bluish beds are more clayey and some of them are almost fissile.	20′
2.	Sandstone, flaggy, gray, hard.....	13′
3.	Sandstone, brownish blue, fine grained, hard and grit like; fracture irregular; in layers one foot or more thick; some layers contain flattened nodules of clay.	15′
4.	Sandstone, irregularly flaggy; clayey; some parts micaceous; fucoids one inch in diameter and more than two feet long.	16′
5.	Conglomerate, pebbles from size of pea to an inch and a half, mostly white quartz, some of dark quartzite and occasionally some of blue limestone and chert.....	0′ 4″
6.	Sandstone, color and structure like No. 3.	3′
7.	Sandstone, flaggy.....	4′ 8″
8.	Sandstone, in color and structure like No. 3; near the top is a ferruginous layer, 2 to 4 inches thick, with *Spirifera disjuncta*, *Rhynchonella*, *Chonetes* and *Edmondia*. Specimens can be obtained only with difficulty as they are indistinct on fresh surface, while the weathered surface is very soft; fine specimens of a large *Goniophora* occur in the other parts of the rock.....	4′
9.	Conglomerate, ferruginous, coarse, many pebbles larger than chestnuts, and mostly white quartz.	0′ 10″
10.	Sandstone, flaggy; contains in middle a fossiliferous layer crowded with *Chonetes*.....	5′
11.	Conglomerate, pebbles smaller than in the others.	0′ 6″
12.	Sandstone, laminated to flaggy, light gray to bluish and reddish-gray; thin layers of laminated shale separate the sandstones; no fossils aside from bits of carbonized wood, indistinct *Calamite*-like stems, some trails and indeterminate fucoids.....	95′

13. Concealed.....103′
14. Sandstone, flaggy but irregular; many layers crowded with *Spirophyton; Productella* present but not plentiful..... 15′
15. Concealed..... 55′

Total of Chemung..... 350′

Hamilton.

16. Shales, areno-argillaceous; dark gray; laminated to fissile; no fossils observed except one obscure *Chonetes*..... 136′
17. Concealed..... 33′
18. Shales yellow to ashen, clayey to sandy..... 88′
19. Concealed in river "bottom"..... 200′
20. Shales like No. 18, laminated to fissile..... 300′
21. Shales, alternating black and gray, probably..... 150′

Total of Hamilton..... 907′

This brings one to the Clinton rocks which form the bench of Clinch mountain, there being no Oriskany or Lower Helderberg. The Pôor valley road from Mendota to Little Moccasin creek lies in Hamilton or Clinton for most of the way and reaches the North Fork of Holston at the big bend about four miles below the creek. Following the curve of the stream, the road soon touches the white sandstone of the Clinton and fragments of fossil ore occur in considerable numbers. But at somewhat more than a mile below Little Moccasin creek, the road and river pass from the Silurian into the Devonian, so that at the mouth of that creek they are in the Chemung, with a cliff of Chemung rocks on the south side of the river and the Lower Carboniferous just beyond.

On Little Moccasin, the Hamilton is shown at the roadside for some distance above Mr. Kutz' house. The Chemung sandstones form the crest of Brushy mountain, which, from this line north-eastward, is an imposing ridge. The lower black shales of the Hamilton are no longer shown, but they are said to have been exposed in a mill-race not more than one-fourth of a mile above Mr. Kutz' house. Everything is concealed thence until beyond the road leading into Brumley cove, where an exposure begins as follows:

Clinton.

1. Sandstone and shales, the latter predominating; dip 27°..... 10′

Medina, upper.

2. Sandstone with thin shale and *Arthrophycus;* much of it snowy white; dip 22°..... 95′
3. Concealed..... 75′
4. Massive sandstone, dip 20°..... 45′

Medina, lower.

5. Red shales and sandstones, dip 20° to 15°..... 400′

Bits of fossil ore occur along the exposure of No. 1, but the ore was not seen in place. The white Medina, with a total thickness here of about 215 feet, forms a handsome cliff on both sides of Little Moccasin gap, the dip at the northerly crest of Clinch mountain being not far from 20 degrees; thence the outcrop extends northwardly to form Brumley mountain east from the gap. The red beds of the lower Medina are moderately well exposed; the higher beds are sandy and tend to be hard. The exposures of red and yellow shales belonging to the Hudson continue until Lilly's house is reached, at nearly three miles from the river, where the Trenton limestone is shown. The exposures between the house and the summit of the gap, somewhat more than half a mile, show little aside from reddish, impure, very argillaceous limestones, in which the dip gradually diminishes until, at the summit, it becomes barely 10 degrees toward south of south-east. Compact limestone begins just beyond the summit and continues until the "bottom" of Big Moccasin creek. It is dark blue, weathers grayish, is in thick layers separated by thin beds of shale, and contains few fossils, only some bryozoans having been seen. Shaly limestones appear in the "bottom," but the massive beds at the base of the Trenton are soon reached and they remain in sight to Hansonville. Very little chert was seen thus far.

Moccasin ridge is beyond Hansonville. White chert is abundant from the first summit of the ridge to Tarr's fork of Moccasin and the massive limestones seen along that stream contain great balls and lenticular masses of black chert. These beds are exposed on the north branch of that fork, where they dip south of south-east at from 15 to 22 degrees. The lower beds shown at the summit between Tarr's fork and a branch of Copper creek have cherty reticulations on the layers so that the vertical surfaces of the beds acquires a fretted appearance. Here one comes to the shales of the Knox group and the road passes into the area drained by the Clinch river.

Returning to Clinch mountain. Medina forms the crest of Brumley mountain, which attains its most northerly extension almost due south from Lebanon and thence has an almost eastward trend into the "loop" of Cedar creek. There at Hayter's gap, the mountain is crossed by the road leading from Lebanon to Saltville, along which the white Medina is seen at the summit and the Clinton shales are reached at, say, half a mile from the Poor Valley road. These shales form the mountain bench which fades into Poor valley and they are shown occasionally along the road until it leaves the valley to pass through Brushy mountain at nearly six miles from Saltville. The axis of the Burk's Garden anticlinal is not shown here, nor is it exposed on Tumbling creek, three or four miles further east, though there both slopes can be recognized.

Tumbling creek is formed by the union of several streams in the north-

erly extension of Clinch. No attempt was made to follow it to its head. The erosion above the first forks is very deep and there is some reason to suppose that Hudson beds have been reached; but as this is merely conjecture the space is colored on the map as Silurian.

The Devonian and Lower Carboniferous are exposed in numerous gaps through Brushy mountain where the Vespertine's notable increase in thickness is very well shown. The upper bluff of the Chemung is more than 200 feet thick and forms a bold cliff.

The "short" road to Saltville reaches the North fork of Holston at somewhat more than five miles below that village and thence follows all the windings of the stream. It exposes the lower limestones of the Lower Carboniferous and excellent collections of fossils can be made at several places. Twice it passes wholly below the limestones and enters the Vespertine, reaching the black shales which contain streaks of impure *coal*. As the road approaches Saltville it leaves the river and goes through a little ravine, in which the massive limestones of the Lower Carboniferous are exposed. The synclinal observed on Wolf run is crossed before Saltville has been reached, but the anticlinal is concealed, as much of the Saltville basin has been eroded from it, the axis passing very near the railroad station. Calcareous shales of the Lower Carboniferous make up the hills on the northerly side of the Saltville basin and are very fossiliferous. These hills are rounded and are so nearly of the same height that they may be remnants of a terrace. The hills on the opposite side of the valley are rugged, heavily wooded and show a cliff of Knox limestone.

The peculiar features of this Saltville basin, with its salt and gypsum will be discussed in another part of this memoir.

Only Cambro-Silurian rocks are shown between Saltville and Glade Spring and the dip appears to be regularly south of south-east. The Walker mountain fault is crossed at but a little way from the water-station, nearly two miles from Glade Spring. The turnpike from Glade Spring to Bristol is, for a great part of the way, very near the line between Knox and Trenton, and for miles at a time the surface material is very red, the characteristic color of this horizon and of another nearly midway in the Knox group.

Walker mountain increases in height very rapidly eastward from Glade Spring and it is soon double, one ridge being capped with white Medina and the other with Chemung. The red Medina is fairly well shown, near Lyons gap, where some of the layers contain many Hudson forms. The yellow shales of the Hudson are not well shown but the limestones of the Trenton are well exposed on the Rich Valley road and thence until near Saltville, where the Knox beds are reached.

In going eastward from Saltville along the Tazewell pike, one finds immediately beyond the first fork of the road an exposure of Lower Carboniferous dipping south-eastwardly, showing that the anticlinal has not been cut away wholly. Beyond the North fork of Holston Lower Carboniferous limestones are shown dipping south-eastwardly, at from 10 to

50 degrees, the rate increasing as Brushy mountain is approached. The pike follows the river to the Broadford, six miles from Saltville. The river cuts into the Vespertine shales at somewhat more than four miles from Saltville and there exposes in the upper division a *coal bed* about 3 inches thick. The hard gray sandstone underlies these shales. A *coal bed* was once opened above this sandstone on the run passing by Dr. Watson's residence about five miles from Saltville; its thickness is not known with any degree of certainty, but is believed to be somewhat more than one foot. That a *coal bed* exists in the lower shales is thought to be probable, as fragments of *coal* have been obtained in the run behind the sandstone ridge. For the greater part of the distance between Dr. Watson's residence and the Broadford, the road lies in Vespertine shales, and at one place a side-cutting exposes two streaks of *coal*.

Beyond the Broadford the road passes into the limestones and does not return to the shales until very near Laurel fork. There the Vespertine beds with sandstone nearly midway are shown with dip of 20 degrees in direction of the stream and having a thickness of not far from 500 feet. The sandstone is between 15 and 20 feet thick, the estimate being made from a somewhat imperfect exposure. The shales rest on a conglomerate sandstone separated by a few feet from reddish brown or bluish brown sandstones of the Chemung, occuring in flags 2 to 8 inches thick, fine grained, with a somewhat conchoidal fracture and exposed along the stream above the mill-dam with a dip of nearly 25 degrees. The sandstone with conglomerate layers, contains much *Spirophyton*, but no fossils were observed in the fragments of the main body of sandstone. This rock is the cliff which forms the crest of Brushy mountain from near Mendota to beyond the line of Bland county.

Débris from this cliff effectually conceals everything on the northerly side of Brushy mountain except at one place, say two miles above the gap, where, however, the wall is precipitous, so that detailed examinations cannot be made. At the same time the sequence of Clinton, Hamilton and Chemung can be made out very clearly. Clinton shales are exposed at the crossing of Laurel fork in Poor valley two miles from the gap, and there one begins to ascend the Poor Valley or Flat Top mountain which marks the course of the Burk's Garden anticlinal and divides the Poor valley. The lowest beds of the Clinton cross the anticlinal here and fragments of fossil ore are abundant at many places on the southerly side of the mountain; the lowest shales are very black. The Flat Top mountain ends at a few miles east from the pike in a clumsy mass known as Bear town. The axis of the fold passes very near to the crest of Flat Top, for at a few rods beyond the summit, the rocks are dipping north-westwardly at 15 degrees. The rate increases lower down the mountain side, where a subordinate fold is shown with dip of 60 degrees on its northerly side.

Clinton shales are well exhibited on the southerly side of Clinch mountain, where two minor folds were seen, one of them overturned. The dip is from 30 to 50 degrees south-eastward. Fragments of fossil ore are

abundant alongside of the road and the ore is shown in place along the reversed fold. It is shown again higher up the mountain, where it carries not a little brown hematite. White Medina is reached at the crest of the mountain.

Returning now to the mouth of Laurel fork. The Saltville fault is reached just beyond the Taylor property at ten miles eastward from Saltville. Thence eastward the road and river are south from the line of fault. The fault is at some distance north from the road at Mr. I. H. Buchanan's property, where Lower Carboniferous is represented only by the lower shaly limestones and the Vespertine shales below. On the first stream entering Cove creek below Mr. Buchanan's house, the Knox sandstones extend fully one-third of a mile northward from the road. *Coal* occurs in the Vespertine shales on Mr. Buchanan's farm where it was opened many years ago. The thickness of the bed is said to be 2 feet at one opening, 18 inches at another; its place is no longer exposed, but the bed lies very near to the gray sandstone. The *coal* burns nicely, but according to Mr. Buchanan it is very sulphurous.

Gypsum occurs in vast quantity on the I. H. Buchanan farm, sixteen miles from Saltville, as well as on that immediately adjoining. It has been obtained on the Taylor farm, ten miles, and on the Pierson farm five miles from Saltville; all of them along this road. These deposits will be referred to in another part of this memoir.

The road lies in the Knox group, east from Mr. Buchanan, and white cherty rock forms at many places the striking feature of the surface. The shales of the group are shown on Black hill and the limestones were followed almost to the county line. The road and river come together again near the mouth of Lick creek.

No obscurity respecting relations of the beds occurs until after leaving this main road and turning up Lick creek on the road leading to Burk's Garden. Except for very short distances this part of the area drained by Lick creek is a wilderness. The course of the stream is very tortuous and one has much difficulty in determining his place. The ridges all become very high and, viewed from Black hill on the main road, appear to be trending toward the southerly boundary of Burk's Garden. Brushy mountain, the Vespertine ridge and the ridge of Knox sandstones, all lying north from the Sharon Springs road, are bold and, as seen through the trees on Lick creek, abrupt. Exposures are very rare until within three miles of the summit of Garden mountain, where Clinton shales are shown. The structure is not wholly simple, for some imperfect exposures indicate the presence of more than one anticlinal in the shales. Lick creek rises on the side of Bear town, the clumsy knob in which the Medina ridges, bounding the Garden, unite.

IV. THE AREA DRAINED BY CLINCH RIVER.

The turnpike, from Abingdon to Wise Court-House, crosses the ridge between Tarr's fork of Big Moccasin creek and a branch of Copper creek at a little way above Mr. G. W. Morton's house. The rate of dip increases rapidly in Knox limestones until at that house it becomes sixty degrees. There the Copper Creek fault is crossed and the shales are shown on the long grade. The dip gradually diminishes and the marbles, first reached near the Sulphur Spring Church, remain in sight to the old Court-House, beyond which the underlying white chert and its ferruginous earth are exposed. As usual, the lower members of the marble group contain great nodules of black chert. Same of the marbles near Williams' store are of decided beauty.

Fossils are very rare, but a somewhat earthy bed on Copper ridge, not far from Dickensonville, on the road to Osborn's ford, contains *Orthis pectinella, O. lynx, Strophomena alternata* and some bryozoans.

The dips are almost regularly south of south-east on both Moccasin and Copper ridge until within about seven miles of Osborn's ford on the latter ridge, where a north-westward dip is distinct. There is difficulty in determining the structure along the crest of Copper ridge, because the rocks are deeply buried by the coating of decomposed material usually containing brown hematite, and always of a deep red color. At little more than a mile and a half from Osborn's ford the dip becomes very irregular, and the cherty limestones and calcareous sandstones are thrown into many and close folds, a condition which is continuous thence to considerably beyond the ford on the road to Guest's station; but all exposures cease in the broad "bottom" at about half a mile from the ford, so that the relation of the Knox limestone to the Lower Coal measures (Quinnimont) cannot be ascertained directly.

The "Hanging Rock" on Little Stony creek, at about a mile from Clinch river, is a massive sandstone belonging to the Lower Coal measures; it dips north of north-west at between sixty and seventy degrees, and the thickness as exposed is not far from seventy feet. The rock contains some conglomerate layers, and it is said to be underlaid by *coal*. This wall is clearly at some distance north from the Clinch fault, as for not less than fifty rods below it the hillsides show great blocks of sandstone, and a somewhat indefinite exposure seems to show the sandstone in place.

The "blossom" of a *coal bed* was seen at the sharp bend of the road, one-fifth mile beyond the wall. The bed appears to be one foot thick; it has shales below and a soft massive sandstone at a very few feet above. So far as exposed, the rocks have northerly dip until the open space beyond Buckner's ridge is reached, where exposures show the dip to be south of south-east. Thence to the summit of this Powell-Stone mountain no exposures were seen aside from fragmentary exhibitions of shale and sandstone. The broad, very gently undulating summit of the mountain is formed by a massive Quinnimont sandstone, fully ninety feet thick, and

varying greatly in color and structure. It is almost white on the unweathered surface, but many parts contain so much iron as to weather yellow to a considerable depth. Much of it is very soft and readily breaks down into loose sand. Many layers are conglomerate with pebbles seldom much larger than a good-sized pea, and the sand covering the mountain summit contains great numbers of these white pebbles. This great sandstone, which in all probability is the "Bee Rock," or topmost bed of the Lower Coal measures, is almost horizontal until within little more than a mile of Guest's river. From the summit to that river no exposures were found; but just above the ford at 585 feet, by barometer, below the last exposure, this rock is shown in the river bank dipping north of north-west at between six and eight degrees. So the great Stone Mountain anticlinal has diminished wonderfully from Little Stone gap, where the dip is almost vertical on this side of the axis.

Guest's station is on Little Tom's creek on the road to Gladesville or Wise Court-House. Between it and Guest's river, the exposures are poor and indefinite. A thick sandstone is shown at several places near the station. The dips grow gentler beyond the station and become insignificant towards Roberts knob, a conspicuous hill half a mile or so northward This hill is capped by a thick sandstone with conglomerate layers, while in the hollows about its base, nearly 700 feet below the top, is a *coal bed*, which, exposed in the beds of runs, has supplied blacksmiths for half a century. The bed is said to be not far from six feet thick, and its place seems to be near that of the *Kelly* or of the *Imboden* bed of the Powell River sections.

On the pike leading to Wheeler's ford, variegated shales are shown at barely half a mile from the station dipping west of north at not quite seven degrees; with them is a *coal bed*, of which the "blossom" is shown at a little way beyond. The road is but little off the strike for some distance, and soon rises to a massive sandstone, under which the "blossom" of a thin *coal bed* is shown at the first summit. Exposures, however, quickly become indistinct as the road descends to a broad basin eroded by several small branches of Guest's river. Here one should cross the axis of the Stone Mountain anticlinal, but, though not far from 650 feet below the "Bee Rock," on the crest of Powell-Stone mountain, yet that rock is not reached, which shows a flattening of the arch at the rate of certainly more than 150 feet per mile.

The Dry fork of Bull creek is reached beyond the next summit, and exposures become as unsatisfactory as can well be imagined. A *coal* blossom was seen near the summit, but thence only fragmentary exhibitions of cross-bedded or irregularly flaggy sandstones occur, which afford no definite measurements of dip. A southerly dip was observed at several places, but it could not be measured. At about a mile up the Dry fork, a sandstone is shown, thirty to forty feet thick, somewhat cross-bedded, and containing small pockets of pebbles. The dip is distinctly northward on Bull creek, where reached by the road, the dip being influenced by the

Clinch fault little more than half a mile away. This dip becomes gentler further up Bull creek, so much gentler that the following measurements obtained in crossing from Bull creek to Russell creek are probably not far out of the way:

Middle Coal Measures.

1.	Sandstone	25′
2.	Shales	10′ to 15′
3.	*Coal bed*	blossom
4.	Sandstone and shale	120′
5.	*Coal bed*	blossom
6.	Sandstone and shale	100′
7.	*Coal bed*	blossom
8.	Sandstone and shale to Bull creek	180′

The intervals between these coals are very suggestive of their relation to beds on Powell river, but one is not justified in making identifications on so slender a basis.

Russell creek is reached by the road at little more than a mile from Clinch river. The dip at Mr. Dickenson's house is distinctly south of south-east. Mr. Dickenson digged *coal* on a little branch of Russell creek at about one-third of a mile north from the road. The exposure is very indifferent, though it extends for more than fifty feet. Manifestly, the dip is considerable, and the coal is very much twisted. Prof. Lesley, in his notes on this region, regards this coal as the same with that mined north from Guest's station.

Coal beds were seen between Russell and Whetstone creeks at 25, 85, 157 and 205 feet above the former stream, and a compact sandstone with nests of very coarse conglomerate makes the summit. The dip varies from 42 to 45 degrees on the Russell side of the ridge, but beyond the summit it diminishes rapidly, and is reversed at an inconsiderable distance. Prof. Lesley gives a diagram of this hill in his memoir. Exposures cease soon after the summit has been passed, and no more occur until beyond the river, the abrupt wall of Knox beds shows that the Clinch River fault has been crossed. The road reaches Clinch river at Kincaid's hole, whence it follows the stream to Wheeler's ford at the mouth of Lick creek. The river crosses the fault about midway between the two points. The ridge marking the course of the fault is cut away for some distance on both sides, but it quickly regains its height, and is very bold where cut by Lick creek at a little way from the river. The immediate line of faulting was not seen, but the rocks are turned up sharply on both sides, the Knox beds dipping south-eastwardly at forty degrees, and a sandstone above the fault dipping even more sharply in the opposite direction. The limestones, however, are more contorted than the Coal Measures beds, for they are thrown into a succession of folds, one of which passes very near to Mr. Field's house, a mile north-east from Lick creek, where the dip is N. 40° E. at 20 degrees.

The road leading to Dump creek past the Harrold's Valley Baptist Church lies south from the Clinch fault. The area of Knox limestone begins to narrow at a little way beyond the church, and a new line of hills, composed of Devonian and Lower Carboniferous, comes in between the road and the Clinch river. These are due to the cross-fault, which unites with the Clinch fault near the Gravel Lick road at Caney fork of Dump creek. This cross-fault is crossed by the Harrold's Valley road just where it emerges from the limestone ridge upon the valley of Dump creek. There one passes at once to the Hamilton shales lying south-east from the Knox limestone and in contact with it. The width of the limestone area here is less than half a mile, and it decreases rapidly, for no limestone crosses Caney fork, and on the east side of that stream the Clinton (?) shales are in contact with the Middle Coal measures along the Clinch fault.

A *coal bed* has been exposed on the Gravel Lick road at the mouth of Bee branch of Caney fork by Mr. A. Kiser. So far as shown, it contains about four feet of good coal, but it dips at 55 degrees toward S. 25° E. The line of faulting passes very near this place on Caney fork, and near the mouth of Hurricane fork further east. Important developments of the coal beds have been made on Hurricane fork, where beds, answering to the *Lower Splint*, the *Imboden*, and an intermediate bed of the Powell river sections, have been opened. The thickness is reported to be greater than at localities on the headwaters of Powell river in Wise county.

The Devonian rocks are well shown along both Dump creek and Caney fork, each of which flows for a considerable distance at the northerly foot of the Brushy ridge, lying between Caney fork and the river. The Chemung rocks are well shown on the road following Caney fork, where they are more fossiliferous than at localities examined in the Holston area. Immediately below the mouth of Caney fork, Dump creek enters a short gorge through this ridge. The St. Louis limestone is reached above the store, the Vespertine apparently being absent. The exposure of the limestone and its associated shales extends for little more than 300 feet. The New Garden fault is crossed in the ravine below the store. Thence to the river the road lies in contorted shales with occasional limestones, belonging most probably to the Knox group.

The Knox limestones dipping south-eastward at thirty to eighty degrees are reached at the mouth of Mill creek on the southerly side of Clinch river. The dip is very irregular and the steeper dips of the undulations are on the south-easterly side. The top of the massive limestone is reached beyond the first mill, and the shales are shown just above. These hard limestones form a line of abrupt ragged hills, which are characteristic features of the Knox topography. Exposures along this creek are not sufficient to show the structure distinctly above Jesse's mill; but the dip appears to be continuous south-eastward. The Trenton marbles are reached near the summit between this and Little Cedar creek, where some of them are remarkably handsome. The clayey limestones marking the top of the Trenton succeed, and the south-easterly dip continues to where the road

crosses Little Cedar creek. There the dip is reversed, and the same beds are shown in Lebanon. This is the House and Barn synclinal, which, however, is double as a second synclinal is crossed by the Fincastle pike at a little way east from Lebanon. The northerly synclinal is crossed again by Little Cedar creek near the second house north from the pike on the road leading to Nash's ford. Thence on that road the rocks rise regularly to the top of Copper ridge. The white chert underlying the marbles rises with the road to the top of the ridge, and its fragments in the deep red detritus cover the surface. This rock bears very close resemblance to the upper layers of the Medina, both in mode of weathering and in fracture; so that one unacquainted with the true condition might readily suppose Medina present along this line. The top of the ridge is a synclinal, or, if not, the rocks have no perceptible dip, for the fragments of chert are abundant along the road for half a mile. They characterize the crest of Copper ridge in Scott county. Brown hematite is abundant. It was mined forty years ago by Dougherty, who had a small forge on Cedar creek above Mr. John Stinson's house. Shales are exposed all the way from the summit of the ridge to Stinson's, where limestones are reached again.

The shales of the Knox group are shown on the north side of Clinch river, at Nash's ford, where, though crumpled as badly as the laminæ of gneiss or mica schist, they show no signs of metamorphism. The road from Nash's ford to the head of Robinson fork of Lewis creek crosses Thompson creek and follows Breeze fork of that stream to its head. This road barely touches the line of the New Garden fault, reaching it only west from the fork of the road half a mile from Lockhart's store on Robinson fork. The line of the fault was not determined here within about one-fourth of a mile, as there seems to be some Lower Carboniferous limestone which was not separated from the Knox limestone. The New Garden fault lies north from the road for two miles east from Lockhart's store on Thompson's creek, but near the head of the fork next east from Breeze fork of that stream, the road approaches very nearly to the conglomerate ridge, fragments of the sandstone being abundant in the road thence for some distance. The fault line certainly passes very near the heads of the several branches of Thompson's creek. No *coal* occurs on any of these streams.

The fault is crossed by the northerly branches of Robinson's fork of Lewis creek at a little way from Lockhart's store. The limestones prevail up the side of Big Butt or Big Axe mountain, fully half way up from the store. The soft limestones have yielded to the action of the many streams forming the two forks of Lewis creek, so that here is a fine agricultural space, known as the New Garden. The structure is somewhat complicated, as appears from Mr. Squier's note already quoted; but the writer's examination was not made in detail, his desire being merely to supplement by a new reconnaissance the reconnaissance work already done by others. Robinson's fork follows a rudely eastward course, and the

lower *coal bed* of the Quinnimont or Lower Coal measures has been digged in ravines coming from the north.

Limestone prevails along Lewis creek to its mouth, and the great calcareous sandstones with thin cherty beds so closely resembling the white Medina are well shown at the Clinch river, which is reached at Black's ford. The Trenton limestones are exposed near the top of the abrupt bluff on the opposite side of the river, and the marbles are shown immediately beyond. Soon one comes to the House and Barn synclinal, which is deeper and broader than on Little Cedar creek near Lebanon, and holds at a little way east from this road the narrow House and Barn mountain with its crest of white Medina. This mountain is little more than a mile and a half north from the Fincastle pike. The easterly side of the synclinal is very abrupt and the Trenton marbles are brought up before the pike is reached at Rosedale, where one is in the red clays filled with fragments of white chert.

The pike crosses the Elk Garden anticlinal at a few rods east from the large brick house belonging to Mrs. Smith. The exposures are somewhat indefinite in much of Elk Garden, as the beautiful region eroded by Cedar creek is termed, and there may be more than one crest to the anticlinal as there are both east and west from this place. The disintegrated clayey material, carrying chert and occasionally brown hematite, prevails along the pike until very near the fork of the road leading to Saltville, so that details of structure cannot well be obtained. But on the Saltville road, near Mr. W. A. Stuart's house, the south-easterly dip is pronounced though comparatively gentle, being only fifteen degrees. It becomes undulating just beyond the next fork in the road, and for some distance the rocks are badly twisted. The Loop anticlinal, very well defined, is crossed within a little way north from the road leading to Saltville by way of Rich mountain.

The marbles of the Trenton are shown on the main road at the foot of the grade leading to Hayter's gap, and Trenton fossils abound just beyond the S-bend in the road. Thence exposures are very good along the grade all the way to the summit of Clinch mountain at Hayter's gap. The dip is south-eastward, and varies from twenty to forty-five degrees; but there are many petty crumplings of the red Medina, even the thicker and harder beds being folded closely upon themselves. The yellow more or less fissile shales of the Hudson cannot be less than seven hundred feet thick, while the red mud beds of the Medina cannot be far from four hundred feet. A fossiliferous layer occurs in the lower part of the red beds, but the fossils are not so good in weathered fragments as those found in Lyon's gap of Big Walker mountain.

Red Medina and Hudson shales form the irregular terrace along the north side of the doubly-pointed mountain known at the west end as Little Bear town and at the east end as Short mountain. This terrace passes round the end of Short mountain into Ward's cove, where it is continuous with the bench along Clinch mountain; this is conspicuous in Thomp-

son's cove, and is continuous along Rich mountain to the gorge of Plum creek.

In descending from the crest of Clinch mountain into the Thompson-Ward cove by the Tazewell pike, one comes quickly to the red, yellow and grayish shales of the Hudson. The admirably engineered road doubles on itself again and again as it descends the abrupt slope until it reaches the Trenton limestones only a little way from the toll-gate. The south-easterly dip is very sharp near the summit, but diminishes so that just beyond the gate it is little more than ten degrees. A much more marked decrease occurs beyond the fork of the road near Schnapp's shop, three and a half miles from Liberty. Thence for nearly a mile and a half the dip is barely perceptible, but at that distance the north-westerly dip is very distinct, and it is especially marked where the road crosses the Dry fork. The Elk Garden anticlinal is reached near Liberty, and shows three petty folds on its crest; one near Mrs. Thompson's house; a second near Mr. Barnes' house, and a third very near Liberty.

The synclinal just south from Mrs. Thompson's house holds Short mountain at the west and, at the east, so much of Rich mountain as lies west from the gorge of Plum creek; this portion, as seen from the Fincastle pike, appearing to have a synclinal structure.

The House and Barn synclinal is quickly indicated on the road leading from Liberty to the mouth of Indian creek. The dip becomes abrupt on Paint Lick mountain, but good exposures are few. White Medina is reached just below the summit, and at the summit is the southerly axis of the double House and Barn synclinal. This trough is deep but very narrow, the width between the Medina outcrops being less than one-third of a mile. Clinton is present; fossil ore is shown near the road and many years ago it was mined in a small way at some distance west from this road. The south-easterly dip on the northerly side of this trough is almost vertical.

The road descends to the valley separating Paint Lick from another synclinal known as Deskins mountain, which is shorter and narrower than Paint Lick. The erosion in the valley has just sufficed to expose the Trenton along the petty anticlinal, which is reached and crossed where the road first touches the little stream. The northerly or Deskins trough of the House and Barn synclinal is very narrow here, for its axis is crossed before the gap through Deskins mountain is fairly entered, and there the first exposure shows the limestones dipping toward the south-south-east. The Trenton beds as exposed in the banks of this stream dip at from twelve to twenty degrees toward south-south east, except at one spot where a very abrupt and close anticlinal is shown. The massive limestones of the Trenton are reached at the first fork of the road, and thence almost to the next fork the road lies largely in the marbles. After turning toward Clinch river it passes into the Knox and quickly reaches the lower shaly beds. Lumps of brown hematite occur here. The dip becomes steeper toward Clinch, being thirty degrees where the road first reaches the river;

thence to the mouth of Indian creek it is irregular, sometimes reaching fifty degrees.

Clinch river cuts the New Garden fault in the bend opposite the mouth of Indian creek. The Knox limestone is on the southerly side of the fault with the Lower Carboniferous shales in contact with it. On Middle creek, these shales are reported to extend to very near the coal mines. The Stony Ridge fault develops quickly, for the Devonian and the Lower Carboniferous are well shown on forks of Indian creek between the New Garden and Stony Ridge faults. The road leading from the mouth of Indian to Baptist valley lies in the shales to Low's fork of Indian, about four miles from mouth of Indian. On Low's fork one comes quickly to the Lower Carboniferous limestones, many of which are full of well-preserved fossils. The bottom of the group is reached at the main creek and the Chemung sandstones with *Productella* and *Spirophyton* are exposed just beyond on Laurel fork. The old Christian *coal mines* on Laurel fork are nearly two miles from the Baptist Valley road, and are in the Lower Coal measures or Quinnimont group. The main fork of Indian creek, rising near J. B. Young's house in the "Sinking Waters" region, flows for most of its length through the Lower Carboniferous beds, though occasionally passing over to the Chemung. Very fine specimens of *Pentremites*, *Terebratula* and *Athyris* have been obtained here.

The road following Indian creek to its head crosses the summit to Dry fork of Sandy river, reaching that stream at about two miles below the Gap store on the Baptist Valley road, the distance being measured along the stream. The course of this stream is very irregular, and often follows the strike of the beds for a considerable distance. The Devonian rocks are exposed at a little way below where the stream was reached, but no details were obtained respecting them or respecting a limestone which was seen at nearly a mile further down the stream.

The Stony Ridge fault is reached at three and a half miles from the Gap store or one mile above the mouth of Dick's creek. There a thick bed of sandstone belonging to the Lower Coal measures is shown at the roadside dipping at a very high angle, while at a few rods further down, but on the opposite bank, D. G. Sayers once opened a coal pit. These rocks continue to the mouth of Dick's creek, beyond which no observations were made along this stream; but the writer was informed at the mouth of that creek that no limestone occurs on the Dry fork between that place and the State line. The limestone certainly makes its appearance within a very little way east from the Dry fork.

The road to Crockett's cove leaves the Dry fork at Dick's creek and turns from the creek northward within about a mile. The Lower Carboniferous beds are reached at about three miles from the mouth of Dick's creek. The limestones form a high ridge, only three hundred feet lower than the Stony ridge, made up of Quinnimont sandstones. The whole strip of Coal measures, fronting on the Stony Ridge fault, is not more than a mile wide. The strip of limestone and Devonian gives the cove, a pleas-

ant little valley, which is evidently continuous geologically with Abb's valley, but is separated from it by a high divide. Stony ridge separates it and Abb's valley from Wright's valley. The limestone strip is very narrow as the dip is abrupt. The Abb's Valley fault passes but a little way north from the fork of the road in the cove so that *coal beds* are accessible within a short distance on that side.

Crossing Stony ridge from Crockett's cove one comes to Cavitt's creek. There exposures are not very clear and the line of the Stony Ridge fault was not seen. The New Garden fault is crossed very near the forks of Cavitt's creek in Wright's valley. It barely fails to show some Coal Measures rocks on its northerly side. From the line of this fault to Jeffersonville on the Fincastle pike, the only rocks exposed belong to the Knox and Trenton groups. All exposures cease soon after Cavitt's creek has been passed, so that the conditions in the House and Barn synclinal along this road are wholly concealed. The southerly side of the synclinal is shown at Jeffersonville with the shaly beds of the Trenton almost vertical. The dips grow gentler as the beds ascend the Elk Garden anticlinal, which the pike crosses at about four miles east from Jeffersonville at a school-house beyond the woolen mill. Thence the dips are comparatively gentle on both sides of the axis.

East River mountain, lying north from the pike and extending eastward to New river, is held in the House and Barn synclinal, and evidently answers to Paint Lick mountain further west in the same trough. Northward from it are two others, very short ridges, both evidently Medina-capped. These were not examined. East River mountain is clearly double, made up of two synclinals, the structure being visible from the Fincastle pike, but better from the summit of Rich mountain. The dip is very abrupt in each of them and the Medina stands in almost vertical walls. The thickness of Clinton cannot fail to be insignificant.

The Plum Creek gap through Rich mountain passes, in all probability, very near the end of the synclinal holding Medina, for at but a short distance further east the mountain is only the northerly side of the synclinal between the Elk Garden and Burk's Garden anticlinals. The red Medina is well shown on the northerly side of Rich mountain along the road leading to Burk's Garden and the white Medina is reached at the summit, where it is dipping south-eastwardly at 40 degrees. The Clinton shales are reached at once and fragments of the fossil ore are shown in the road.

The dip is reversed at a little way down the slope and for a short distance is very abrupt; but it diminishes so that at the mouth of Wolf Creek gap through Garden mountain the dip on the northerly side of the Burk's Garden anticlinal is barely 20 degrees. White Medina forms a fine cliff on the sides of the gap, while the harder rocks of the Clinton are shown at the mouth. Clinton beds underlie Wolf Creek valley between Garden and Rich mountains.

The dip increases abruptly within Burk's Garden, the Trenton shales showing 40 degrees north-west. Few exposures were observed in this "gar-

den ;" the surface is gently undulating and is covered with a deep soil. This is a beautiful cove, precisely similar in type to the anticlinal coves occurring so frequently in the regions of Pennsylvania, bordering on the Great Valley. The wall of Medina, with its terrace of Hudson and red Medina, is unbroken save by the narrow gap through which Wolf creek passes.

V. THE SALT AND GYPSUM DEPOSITS OF THE HOLSTON VALLEY.*

The salt and gypsum deposits found in the vicinity of Saltville, and at several other localities eastward along North Fork of the Holston and its tributary, Cove creek, possess great economical importance and scientific interest.

A basin of remarkable beauty at Saltville extends on both sides of the Saltville fault, having been eroded in hard silicious beds of the Knox on one side and in the Lower Carboniferous shales on the other ; the length is not far from one mile. The narrow westerly portion, drained by a stream rising in the Knox hills and flowing to the North fork of Holston, is separated by a well marked divide from the principal basin, which, within the memory of some of the older settlers, was occupied by a lake ; now, however, it is drained by a little stream which flows to the river. The salt works are in the larger or eastern portion.

The character of the rock on the divide is well shown in the railroad cut about one-fifth of a mile from the railroad station and almost directly behind Mr. Robinson's house, where it is a conglomerate of red to blue clay, sandstone and large fragments of the chert or cherty sandstone of the Knox group. These are cemented by more or less crystalline gypsum. Remains of *Mastodon* were obtained in this cut, which were deposited in Emory and Henry College, on the Norfolk and Western Railroad, eight or nine miles from Saltville. This conglomerate, which is nearly 100 feet thick in a shaft sunk by Mr. Robinson just north from the railroad, has been eroded from the larger basin as well as from that portion lying west from the divide ; no trace of it occurs elsewhere in the neighborhood.

Gypsum is mined in large quantities by Mr. Robinson immediately west from the divide. It is reached at but a few feet from the surface, clearly has a covering of blue clay, and exhibits many seams of red clay, which are sometimes so extensive as to injure the market value of the gypsum. The rock in the large excavation appears to be without dip and most of the material is saccharoidal, comparatively little crystalline gypsum having been seen by the writer. The presence of gypsum on the divide, under

*I am under very material obligations to Mr. W. Musselwhite and Hon. C. T. Smith, of Saltville, for assistance in gathering information respecting the salt and gypsum deposits. Mr. Musselwhite, who had charge of the boring operations in the vicinity of Saltville, generously placed all of his results at my disposal.

the conglomerate, has been fully proved by Mr. Robinson, who took out large quantities from a shaft 125 feet deep. A large mass encased in clay was exhausted on this property. Seams of indurated black clay are not uncommon here and occasional fragments of sandstone have been seen, but no fragments of limestone are reported. Borings made on Mr. Robinson's property were pushed to the depth of 600 feet without reaching bedded rock. Salty material was obtained at 400 feet, but as the boring was dry, brine was wanting and no attention was paid to the salt. After passing through the conglomerate and the underlying blue clay, the drill pierced only gypsum and red clay.

Crossing the divide from the Robinson works, one comes to the Salt-works, whose interesting history would be out of place here. Many years ago a shaft was sunk in search of salt. It passed through 20 feet of blue clay and then 195 feet of red clay and gypsum, reaching at 215 feet abundance of rock salt associated with red clay and gypsum. The supply of brine proved insufficient and after a number of years a well was bored at a distance of a few yards. A large body of water was struck in this at 120 feet from the surface, which immediately rose to within 40 feet of the well-curb. By advice of Mr. Musselwhite, the shaft was connected with the new well by means of a tunnel passing through the saltrock, so that now all pumping is done at the shaft and the supply of brine is apparently inexhaustible. The curb of the well is approximately 45 or 50 feet above the Holston crossing, one-fourth mile beyond the end of the railroad track, so that the almost constant level of water in the wells is practically the same with that of the Holston bed. This great body of water in flowing through the rocksalt becomes almost saturated, 90 per cent; 20 gallons yield one bushel and there appears to be a minimum of bitter waters. The salt when taken from the pans is permitted to drain over them for an hour or two; it is afterwards thrown into bins where the dripping continues for several weeks. The salt is then dry and no longer affected by atmospheric conditions; no rewashing is necessary. Of course, the brine is saturated with gypsum, which is precipitated upon the pans, forming a crust usually spoken of as "rock salt." This deposit, containing not a little salt, accumulates rapidly and adheres so closely to the pans that the labor of removing it adds much to the cost of producing the salt.

The saltrock is at little more than 200 feet from the surface at the well. Mr. W. A. Stuart, President of the Holston Salt and Plaster Co., states that the salt continues to a depth of nearly 600 feet.

The Pierson Plaster Works are on the Holston at nearly five miles east from Saltville. These are idle, but they were worked vigorously for more than five years and the excavations were carried to the depth of 60 feet. The deposit is in the broad river "bottom," and everything points to conditions similar to those seen at Saltville. The soil is underlaid by blue clay which, wherever examined, rests on gypsum, its thickness being approximately 12 feet. No deep borings have been made here to determine the vertical extent of the deposit. Gypsum was once quarried directly under

a bluff on the opposite side of the river on the Miller farm, but the pits were full of water when the locality was visited, so that no information could be obtained respecting the relation of the gypsum to the bedded rocks. On the Pierson place, the gypsum rests on the shales and lower limestones of the Lower Carboniferous.

Explorations for gypsum and salt were made on the Taylor farm at ten miles above Saltville. Here again is a broad river "bottom," very similar to that at the Pierson place, five miles lower down the river. A deep shaft or boring was made here; gypsum was reached under the blue clay at a few feet from the surface and some salt was found first at about 300 feet from the surface. The original "bottom" evidently continued on the north side of a low hill, for there at some distance above the road gypsum has been obtained. The Saltville fault passes through this property and the gypsum appears to be on both sides of it, so that it rests on the calcareous sandstones of the Knox and on the calcareous shales of the Lower Carboniferous.

Buchanan's Plaster Cove on Cove creek and its tributaries is nearly six miles further east. It lies north from the road leading to Sharon Springs and occupies a broad "bottom" on Cove creek, whence it is continuous over a low divide to the "bottom" of a tributary stream on the adjoining farm. The earliest pits were sunk on Cove creek "bottom," near Mr. I. H. Buchanan's former residence. Many shallow excavations were made in order to obtain plaster for agricultural use and a shaft nearly 600 feet deep was put down by Mr. Buchanan to ascertain how much gypsum he owns. This shaft passed through only gypsum and red clay and stopped in that material. The red clay appears to be in comparatively small quantity. As at the other localities the soil rests on blue clay and gypsum has been found everywhere on the "bottom." A little drain comes down the hillside, its channel-way eroded in Vespertine shales which are exposed on both sides; gypsum occurs at its head and no doubt is continuous with the main mass below.

The "bottom" ends at the foot of the Vespertine ridge, nearly a mile from the Sharon Springs road; but a low divide separates it from a tributary which enters Cove creek at about one-third of a mile below Mr. Buchanan's present residence. The rise on this divide is gradual and a narrow strip of gypsum has been traced over it in a succession of pits. Some exceedingly impure limestone is shown at a little distance from the gypsum, but the latter evidently rests on the Vespertine shales. The stream rising on the other side of the summit flows over the shales into the next farm where it has a broad "bottom." Mr. Buchanan has digged gypsum at the very head of this stream and the work continues down the stream. The quarrying has been conducted in a very wasteful manner on the next farm, where a great number of shallow broad pits sufficiently show the enormous amount of gypsum present. Blue clay, often very tough, everywhere overlies the gypsum and at several pits seems to enclose it. The deposit ends on this stream at somewhat more than a third of a mile from

Cove creek, and all of it is north from the Saltville fault, so that it rests wholly on the Vespertine shales. Mr. Buchanan states that gypsum has been digged in very considerable quantity at the road, where this stream enters Cove creek. That gypsum rests on Knox beds. How extensive it is has not been ascertained.

No investigations have been made here with a view to the manufacture of salt and no notes were taken respecting the depth at which salt was first found. Mr. Buchanan's shaft is now full of water and no examinations can be made. There is, however, no room for doubting the occurrence of salt there in the deeper portions. Mr. Buchanan says that the waste material, clay and impure gypsum, was thrown into heaps, to which cattle and sheep resorted, licking them with great avidity. The gypsum is mostly saccharoidal, but there is a good deal of crystalline also. As the latter clogs the mill in grinding it is much disliked and is thrown aside as worthless. Much lies in the waste-piles on Mr. Buchanan's farm which would be excellent for collections.

Mr. Musselwhite states that no gypsum has been found east from this cove on the road to Sharon Springs, and that no gypsum has ever been obtained in the Rich valley which follows the northerly foot of Big Walker mountain.

Resume.

Such are the details obtained either by personal observation or by careful inquiry of those who are familiar with matters no longer open to examination. The facts with reference to the occurrence of these gypsiferous deposits may be summed up as follows:

First. The gypsum deposits are not beds of Carboniferous or Cambro-Silurian limestones changed into gypsum.

Second. These deposits occupy deep basins, which have been eroded in Lower Carboniferous shale or limestone, or in the hard, slightly calcareous sandstones of the Knox group. In at least two localities, branches protrude from the main body into drains or ravines, so that the horizontal plan resembles somewhat the splash made by throwing soft mud against a wall.

Third. The character of the deposit is wholly independent of the rocks on which it rests.

Fourth. The gypsum occurs in irregular masses, encased in red marly clay, which penetrates the gypsum to a variable distance; there is less of this clay in the eastern basins than at Saltville.

Fifth. At a variable depth, salt occurs with the gypsum, and this salt contains very little of iodides or bromides.

Sixth. Blue clay overlies the gypsum at all localities yet examined.

Seventh. No fossils of any sort have been found thus far in the gypsum, its encasing red clay, or in the overlying blue clay; but, just west from Saltville, a conglomerate, cemented by gypsum, occurs, in which remains of *Mastodon*, have been found; this overlies the blue clay, and encloses many fragments of both blue and red clay.

Eighth. These gypsiferous deposits occur in the vicinity of the Saltville fault.

Age of these Deposits.

The basins occupied by the gypsum deposits are very deep, extending more than 600 feet below the present surface at Saltville; more than 400 feet at ten miles east from Saltville; and more than 600 feet below the surface in Buchanan's cove—those being the depths to which exploration has been carried at the several localities. These basins must have been eroded at a time when the continental elevation was greater than now or when the drainage was in a very different direction. It may be suggested that they are great "sinkholes," similar in kind to those which occur so commonly in limestone districts. But there is no probable outlet for waters eroding caverns at more that 600 feet below the present drainage lines; more, the limestones are too far under Pearson, Taylor and Buchanan for their removal to have much effect. The gypsum at those localities rests on Vespertine, between which and the nearest limestones the whole Devonian, Silurian and the upper part of the Cambro-Silurian intervene.

Nothing has been obtained going to show when these basins were eroded. The extent of erosion prior to their formation was very great, for the Coal measures, Lower Carboniferous, Devonian, Silurian and much of the Cambro-Silurian had been removed from the upthrow side of the fault—a very gradual process, as gradual possibly as that by which the fault itself was produced. But nothing can be predicated on this. Geologically speaking, the time required for the removal of 10,000 or 12,000 feet of rock is comparatively short, as abundantly appears from the enormous erosion done in the Colorado area since the later Tertiary and on the Canadian plains of New Mexico since the later Pliocene, where a greater amount of rock has been removed during a period probably no longer than that during which the great faults of Virginia were forming.

One might at first suppose that the blue clay may eventually afford some clue by yielding fossils. It immediately underlies the Quaternary conglomerate of the Saltville basin and everywhere rests on the gypsum. But certainly it was not formed at once after the gypsum ceased to be deposited. The conditions observed on the Buchanan and Taylor properties show that a very considerable thickness of gypsum had been removed by erosion before the blue clay was deposited; possibly more than 100 feet, the strings or branches of gypsum protruding into the little ravines being remnants which had escaped erosion. In every instance, the blue clay rests on eroded bosses of gypsum and does not invade the deposit to a depth of more than a few feet, the investing material being the red clay, which clearly has a different origin. It is sufficiently evident then that a gap exists between the close of the gypsum-making and the beginning of the clay deposit that positively prevents any linking of them together.

But the amount of the erosion and the general relation of the gypsum to the blue clay, with the relation of the latter to the Quaternary conglomerate, suggest that the gypsum is not older than the Tertiary; until some fossils have been discovered, however, the question of age must be re-

garded as undetermined. Fossils may be present and may have been overlooked by the workmen; examinations by geologists have been of the most casual sort, so that the statements respecting absence of fossils are necessarily of no positive value. Capellini's studies in the Tuscan deposits, as well as elsewhere in Italy, bear this statement out; for after the gypsum and its associated marls had been pronounced non-fossiliferous by many geologists, an extensive fauna was discovered, which he has described and illustrated in his numerous memoirs.

Origin of these Deposits.

So long as these deposits could be regarded as of Lower Carboniferous or Cambro-Silurian age, there seemed to be little difficulty in accounting for them as beds of limestone changed by the action of acid springs or as beds of gypsum actually deposited as such from the ocean waters. Improbable as the former explanation might appear in this region where sulphurous springs issue in many places from limestone without having any gypsum in the vicinity, yet it is altogether possible, for Capellini* tells of instances near Cervaro in Naples, where, by the action of hot sulphur springs, nummulitic limestone has been converted from crystalline into fibrous gypsum, containing sandy veins and semi-opal derived from silica of the nummulites. Occasional masses of unchanged limestone were seen there, doubtless owing their preservation to some difference in composition.

The other method of accounting for the beds is even more readily to be received. Newberry has shown for a part at least of the Salina† gypsiferous deposits that the gypsum was most probably deposited as such in lagoons, and the writer has described beds of saccharoidal‡ gypsum deposited as such in the Carboniferous and Triassic of Colorado.

But this deposit belongs not to any regularly bedded series, so that some other explanation must be sought. Any suggestion of deposit from seawater must be set aside at once for the deposit is fully 1700 feet above tide and there is practically no bitterwater in the brine at Saltville. We have to explain the occurrence of gypsum, rocksalt, red marly clay; the gypsum occurring in great amygdules at 1700 feet above tide, in the vicinity of a great fault, and with many sulphur springs still active in the region.

The general mode of occurrence is very like that of the Permian deposits near Recoaro in Venice, as described by Taramelli.§

The gypsum is in amygdules of great size, accompanied by pale sandy marl, looking like volcanic ash, but distinctly calcareous. Capellini‖ in his

*Capellini. Ariano e dintorni. Cenni Geologici sulle Valle dell' Ufita, etc. Mem. dell' Accad. di Bologna, 1869, pp. 15 et seq.

†Newberry. Report of the Geological Survey of Ohio, Vol. ii, p. 194.

‡Stevenson. U. S. Explorations west of the 100th Merid., Vol. iii, pp. 364, 379, 380.

§Taramelli. Geologia delle Provincie Venete, 1882, pp. 69 et seq.

‖Capellini. La Formazione Gessosa di Castellina Marittima. Mem. Accad. Sci. di Bologna, 1874, pp. 16 et seq.

interesting memoir on the gypsum deposits of Castellina Marittima tells of conditions very similar. The amygdules of gypsum are of large size, and are associated with marly gray to yellow clays. He ascribes the formation of this gypsum to the action of sulphur springs on calcium carbonate held in solution; so that the carbonate was changed into sulphate and deposited as such in the littoral lakes of the Middle Miocene. Dr. Newberry, on the authority of Dr. J. M. Locke, has informed the writer that something very like this is going on in Lake Utah, where the calcareous wash from the Wasatch mountains at the east meets the pyritous wash from the Oquiah range at the west, so that calcium sulphate is depositing in the lake.

The origin of the Holston gypsum is to be accounted for in some similar way. Several deep basins were occupied by lakes; that of the Saltville basin received not a little calcareous matter from the Lower Carboniferous beds forming its northerly shore, and some doubtless was received from the wash of the Knox beds on the southerly shore; in the basins further east the calcareous matter derived from the wash should be far inferior to the argillaceous matter. But the composition of the gypsum shows *less* of the red clay at Buchanan's than at Saltville. The principal source of the calcareous matter must be looked for not in the wash from the shores, but in springs. That calcareous springs can produce deposits as extensive as those of this region is sufficiently shown by the extensive deposits around many of the springs at the far West. The calcium carbonate in solution would be converted into calcium sulphate by the sulphurous springs also issuing from the fault, and the gypsum would be deposited as such.

The red marly clays were derived from the wash, and are more abundant at Saltville, where the soft red shales at the top of the Lower Carboniferous are fully exposed on the northerly side of the basin. Undoubtedly not a little of the gypsum is derived from this wash, but, comparatively speaking, the quantity must have been insignificant. Had the basins been very large, such as that of the ancient Lake Lahontan, so well described by Mr. I. C. Russell,* the detrital material would have been dropped at the shore, and the calcareous matter would have been deposited by itself in the middle of the lake; but the Holston basins are very small; the region is one which always had a great rainfall, so that the wash of sand and clay would be very considerable. The amount of foreign matter and its distribution in the gypsum are conclusive. The sodium chloride must have come from springs and it may have been derived from the great sandstones under the valleys. Whatever was the source, the supply appears to have been cut off at about the same time throughout the whole region, for the top of the "saltrock" is reached at 215 feet at Saltville and at 300 feet in the Taylor shaft or at approximately the same absolute level.

Cafici, in his observations of the Sicilian gypsiferous deposits, and Capellini, in his studies of the Tuscan deposits, find evidence of alternating periods of activity and quiet in the springs; for the fossiliferous shales

* Russell. Sketch of the Geol. Hist. of Lake Lahontan. Third Annual Report U. S. Geol. Surv., 1881, 1882.

and marls occur between the gypsums. The opportunities for examination in the Holston region are so limited that one cannot determine whether or not any such variations in activity of the springs occurred there.

NOTE.—The map accompanying this memoir is based on the old State map as used by Mr. Boyd in his Resources of Southwest Virginia, but the scale has been changed and a number of alterations have been made. It is still very inaccurate, but no better map is in existence. I have to acknowledge the courtesy of Maj. Powell, Director of the U. S. Geological Survey, and of Mr. Gannett, Chief Topographer of the Survey, in supplying photographic copies of the unfinished maps of the region. These have afforded real aid in working out the geology at localities where the other map had led me into serious error.

Some Notes Respecting Metamorphism. By John J. Stevenson, Professor of Geology in the University of the City of New York.

(*Read before the American Philosophical Society, December 7, 1884.*)

I have gathered together in this paper a number of notes made from time to time respecting the effect of certain agencies, which are regarded usually as especially active in inducing metamorphism of rocks.

Effect of proximity of Metamorphosed Rocks.

The following section was obtained on Four-mile creek, a stream entering South Park, Colorado, from the west; the rocks are Siluro-Cambrian:

1. Limestone, much altered.
2. Conglomerate and quartzite, imperfectly exposed.
3. Concealed, with occasional outcroppings of quartzite.
4. Quartzite.
5. Limestone, arenaceous, somewhat changed.
6. Sandstone, unchanged, light gray.
7. Sandstone, unchanged, shaly partings, dark gray.
8. Sandstone, slightly changed with layers of unchanged shale.
9. Sandstone, somewhat changed, very micaceous, dark.
10. Quartzite, mostly white, lines of cleavage distinct.
11. Granite and gneiss.

The total thickness of section is not far from 350 feet. A structureless quartzite rests on the Archæan, but above that the degree of change di-

minishes to the top of No. 6, that and the underlying stratum being wholly unchanged, so far as the eye could determine; above these the change is distinct, for Nos. 2, 3 and 4, are perfect quartzites so far as they are exposed. The agent which can convert sandstone into structureless quartzite does not suffice to effect much change in limestone, for the limestones of the section are rendered merely brittle, there being no trace of crystalline structure.

Rocks of the same age at the head of West Fork of Taylor river, also in central Colorado, show a somewhat similar condition:

1. Quartzite, black.
2. Quartzite.
3. Shales, somewhat arenaceous and almost unchanged.
4. Quartzite, structureless.
5. Sandstone, little changed.
6. Quartzite, on top completely changed; middle, the change is slight; but at base the quartzite is structureless.
7. Granite.

The total thickness of section is not far from 250 feet. The conditions are more marked here than in the previous section, for in No. 6, which appears to be a continuous mass, the change is least in the middle. No. 5 is a thick stratum lying between thicker ones, which have been wholly changed, yet it seems to be wholly unchanged.

The unchanged rocks in each section are more or less argillaceous.

The Cretaceous rocks in South Park, Colorado, show some interesting differences, though the conditions appear to be precisely the same. On the west side, where the South fork of the Platte river breaks through a low ridge, the sandstone and conglomerate of the Dakota rest on gneiss and show no evidences whatever of having been subjected to any metamorphosing agent; on the east side near the Sulphur Springs, the same beds are found in the same relative position, but entirely changed, the conglomerate being converted into remarkably beautiful quartzite. The Colorado limestone on this side has been changed in color and it breaks along well defined planes. The Dakota beds are shown west from the main divide at the junction of Taylor and East rivers, where they are resting on gneiss and are wholly unchanged.

The Carboniferous rocks rest directly against the Archæan at the head waters of the Purgatory river in Southern Colorado, but no evidence of metamorphism appears there, which is perceptible to the unaided eye. So also on Cebolla creek, a tributary to Mora river in New Mexico, limestone of Carboniferous age is seen resting on granite and wholly unchanged; but on Manuelitos creek, only a few miles away, the following section is shown:

1. Sandstone and shale, wholly unchanged.
2. Sandstone becoming quartzite below and passing imperceptibly into

3. Silicious limestone, which can hardly be distinguished from quartzite by mere optical examination.
4. Concealed, 25 feet.
5. Gneiss.

The total of the section to the gneiss is about 140 feet. The same section is exposed by a fault at not more than a mile further down the stream, but no traces of change appear.

Effect of Pressure during Plication.

The stratigraphical disturbance in the vicinity of Rock creek, a stream flowing amid the Elk range of central Colorado, is extraordinary. The structure was worked out by Mr. Holmes of the U. S. Geological Survey, whose discussion of the matter is one of the best relating to complicated stratigraphy.

In 1873, the writer made a section across this strange fault-fold.

Beginning at the mountain top on the east side of the valley and descending towards the stream, fifteen strata of sandstone and limestone were found, all wholly unchangcd ; the sixteenth in the series is a slightly altered sandstone, while the seventeenth and eighteenth are thick sandstones, for the most part unchanged, but embracing thin layers of quartzite. Below these are the Cretaceous shales, in the middle of the fold, along the synclinal, but wholly unchanged.

Beyond the stream the rocks are all changed to some degree and the succession is :

1. Quartzite, structureless.
2. Quartzite, imperfect.
3. Silicious limestone, unchanged.
4. Quartzite.
5. Concealed.
6. Quartzite.
7. Shale unchanged.
8. Gypsum, anhydrite.
9. Limestone, shaly, unchanged.
10. Quartzite.
11. Gypsum, anhydrite.
12. Sandstone, somewhat changed.
13. Sandstone, much more changed than the last.
14. Gypsum, anhydrite.
15. Quartzite, showing no trace of lamination.
16. White quartzite.
17. Quartzites alternating with thin limestones; former wholly changed ; the latter almost unaffected.
18. Limestone, wholly unchanged
19. Quartzite wholly changed.

There are no great dikes here, nor are the beds very near the Archæan

rocks. The length of the section as given is not far from 1100 feet. The extent of change increases with the distance from the median line of the fold.

A fact observed here is very worthy of note. One of the conglomerate sandstones of the section contains fragments of Quartzite sometimes resembling the Silurian quartzites seen elsewhere, but oftener resembling the Carboniferous quartzites of the vicinity. The age of the fragments is unimportant in this connection; it suffices to know that the metamorphosis had taken place before the conglomerate in which they occur was formed. On Eagle river, not many miles eastward from Rock creek, the Carboniferous conglomerate contains fragments of Silurian quartzites and the unchanged Carboniferous rocks rest on the wholly changed Silurian beds. It appears hardly probable that anything connected with disturbance or folding of the rocks caused the metamorphosis of the earlier beds, for there certainly was no upheaval or serious disturbance between the close of the Silurian and the Carboniferous, as the two series are conformable, though the succession is far from being complete.

The Dakota sandstones are almost wholly metamorphosed into quartzites along the Conejos trail, which crosses the San Juan mountains from Tierra Amarilla in New Mexico to Conejos in Colorado. The most of it is a structureless quartzite. Along the same trail, the Triassic beds are metamorphosed.

The Dakota sandstone is quartzite on the easterly slope of the Sangre de Cristo mountains in Southern Colorado.

But in many instances the severest twisting and plication appear to have been without any influence whatever. The Dakota is turned on edge and often faulted for a long distance along the easterly foot of the Culebra range of mountains in Southern Colorado and Northern New Mexico, but it shows no change anywhere except where, for a little distance, it has been affected by the proximity of a dike.

The Middle Appalachian region affords many instances in which shales and sandstones have been subjected to enormous pressure and distortion without any apparent effect.

Along Clinch river in Russell county of Virginia, in the vicinity of the Clinch fault, the shales of the Knox group are twisted as badly as mica schists are in many localities, yet they show no signs of metamorphism and have not even new planes of cleavage. The Lower or Red Medina on Clinch mountain in the same county is thrown into close wrinkles which affect even the harder beds, yet no approach to change is manifest to the eye. Within the same region in Pennsylvania, the conditions are similar. In Bedford county, of Pennsylvania, the Red Medina is thrown into extremely close folds for a distance of more than 1000 feet along the easterly side of Evitts mountain, but no change appears in the rock. At a little way further east are the shales of the Hudson and Utica standing on edge but not showing slaty cleavage. There is, however, a change in the Utica, the black shales, which is noticeable here as well as further east

on the easterly side of Tuscarora mountain in Franklin county of Pennsylvania. During the folding, the rock yielded and was broken into great masses which moved on themselves so as to permit the folds to be made. These planes of fractures are the "dry seams" of the tunnel-men.

This condition is equally well marked in the great sandstones of the region. No traces of it appear on the surface, aside from the presence of occasional planes along which silicious matter appears to have been deposited and which have a slickensided surface. But in the great tunnels now driving by the South Penn. Railroad Company, the true condition is sufficiently clear. The crush broke the sandstones into enormous wedges; during the folding these were rubbed against each other so as to polish the faces and to fill the crevices with clay. These are a source of danger and anxiety to those driving the tunnels and they render arching necessary where the rock is such that arching would be thought wholly unnecessary.

The fracturing in the Utica shales is even more noticeable, for there the masses are much smaller and the fragments which fall from a tunnel roof, even when the beds are standing at ninety degrees, vary from five to five hundred pounds weight, while the slates show the results of the terrible pressure by their slickensided surfaces, separated by not more than an inch. Yet despite this terrible pressure, the black shales of the Utica appear to have lost none of their carbonaceous matter and, on the freshly fractured surface, do not differ from shales of the same age in Central New York where the disturbance has been practically nothing whatever.

The sandstones of the Vespertine and Upper or White Medina, in like manner, show no change whatever. The White Medina in its upper portion resembles quartzite, but this is due to conditions during its deposit.

Effect of Contact or Proximity of Eruptive Rocks.

The influence of eruptive rocks is as variable as that of the other agencies. Near the head of East river in Colorado, not far from the head of Rock creek, a narrow dike of trachyte cuts the Colorado shales, and they have been changed into true slate for many feet on each side. At other localities on the same stream, enormous trachytic overflows, nearly two thousand feet thick, rest on the shales. Metamorphism extends to a distance of only a few inches. Nor indeed do the shales show any change as the results of the enormous pressure of the overlying trachyte.

Dikes are very numerous in the San Juan region of Southwest Colorado.

The eruptive rocks appear to equal the sedimentary rocks in quantity. The effect on the latter is very marked, for in many places the metamorphosis is so great that one has difficulty in determining that he is not examining an eruptive rock.

In the vicinity of Old Baldy, a trachytic mass just north from Cimarron creek in New Mexico, there are many dikes which reach far out toward the east, invading the whole of the Cretaceous from the Dakota to the Laramie. There, Colorado shales have been changed into true slates;

the purer sandstones into quartzite and the micaceous sandstones, thus altered, so resemble granite that one examining only a hand specimen might well hesitate before deciding the name of the rock. The miners in the region stoutly maintain that this is granite.

Intruded sheets of basalt have converted coal into coke in Purgatory, Dillon and Upper Canadian cañons in the Trinidad coal field of Colorado and New Mexico. On the northerly slope of the Placer mountains in New Mexico, an enormous dike of trachyte has converted a bed of coal into anthracite for a distance of certainly one-fourth of a mile.

But in many cases the effect is imperceptible. Along the Upper Arkansas in central Colorado, especially in its great cañon passing through the east side of the Sangre de Cristo mountains, known further north as the Park range, numerous instances of contact between eruptive and sedimentary rocks were observed. The Carboniferous rocks dip very sharply near Pleasant valley and an overflow of basalt rests on their upturned edges. There seems to be no alteration at the line of contact. At a little way further up the river, an enormous dike breaks through the same sandstones and overflows broadly; the line of contact is well-shown on each side. Careful examination disclosed no perceptible alteration in the sandstones. At several localities within this cañon, the great sheet of lava, which extends from the eruptive area at the south-west almost continuously into South Park, is frequently seen following the eroded surfaces of the sandstones and coming down almost to the level of the road. Many opportunities occur for examination of the contact, but one rarely finds the alteration extending to more than a very few inches. These rocks are micaceous and contain a large proportion of argillaceous matter.

On Mount Lincoln, near South Park in Central Colorado, a great dike can be seen for nearly 2500 feet above the timber line, passing directly through the Silurian and Carboniferous beds. The effect on the Silurian cannot be determined as some other agent has metamorphosed those beds throughout. The change in the Carboniferous is insignificant. The limestone is altered slightly in color and is somewhat brittle, while the sandstone has become an imperfect quartzite. In each the change is perceptible for a very few feet.

In Dillons cañon, New Mexico, a sheet of basalt is shown between sandstones at a mile from the cañon's mouth. No effect whatever has been produced on the character of the rock, though vapor holes are present, showing the intense heat; yet at a short distance further up the cañon the same sheet has converted into fine quartzite the sandstone on which it rests.

In the Upper Canadian cañon a sheet of basalt has converted a coal bed into coke, but another at a few feet higher up the hill has had no influence whatever on the rock in contact with it.

On the northerly slope of the Placer mountains a narrow dike of basalt cuts through the Laramie beds, its course being fully exposed for 38 feet, including two thin beds of coal. No effect whatever has been produced on the coal even at the line of contact.

Twelfth Contribution to the Herpetology of Tropical America.
By E. D. Cope.

(*Read before the American Philosophical Society, Dec. 19, 1884.*)

I. On a Collection of Fishes and Reptiles from Monterey, Nuevo Leon, Mexico.

The following list represents a collection which I made when on a visit to Monterey, in the month of November, 1883. The locality is an important one from the point of view of geographical distribution, as it is on the borders of the two great realms, the neotropical and the nearctic. How well it expresses this position may be seen from the accompanying identifications.

Pisces.

Amiurus olivaris Raf., a large specimen obtained in a fresh state, from the Salado river.

Campostoma formosulum Girard.

Hybognathus civilis, sp. nov.

Scales 6-41-4; Radii; D. I. 8; A. I. 8. Length of head equal depth of body, and contained in the total length (including caudal fin) 5.25 times. Eye contained 3.66 times in length of head, and 1.25 times in interorbital width; its form oval. The muzzle is obtuse at the extremity, and overhangs a little the premaxillary border. The mouth is small and horizontal, and the lips are not sharp-edged. The extremity of the maxillary bone is opposite the anterior nareal opening, not reaching the orbit by some distance. Infraorbital bones narrow. Frontal region convex transversely, with two rows of tubercles on each side of a smooth median space in the males; the two interior rows coming together on the middle line on the top of the muzzle. The rays of the pectoral fin are thickened in the male, and they do not reach the ventrals. The ventrals do not reach the vent, and their anterior origin is a very little in front of the anterior origin of the dorsal fin. The gular isthmus is wide.

Total length, .078; do. to opercular border, .010; do. opposite base of dorsal, .032; do. to opposite base of anal, .044; do. to base of caudal, .065.

Color, dusky above; below silvery with dusky shades; fins yellow at the base, unspotted.

This species is very abundant in the creek that rises in a large spring in the city of Monterey. Its nearest relative is the *H. flavipinnis* Cope from Western Texas. The latter differs in the larger eye, which enters the head 2.66 times, and equals the interorbital space, which is flat and not convex. There is also a distinct lateral band in the Texan species, which is in the *H. civilis* only faintly indicated. The characters are constant in small as in large specimens.

CLIOLA MONTIREGIS, sp. nov.

Related to the *C. jugalis* Cope, but more elongate in form, and with but eight anal rays. Scales 6–36–2½; Radii; D. I. 8; A. I. 8. Head entering length (without caudal fin) 3.5 times; depth entering the same 3.75 times. Eye entering head 3.2 times, and into interorbital width 1.2 times. The scales are rather closely imbricated. The dorsal outline is gently arched from the muzzle to the last dorsal ray. Caudal peduncle stout. Mouth terminal, descending backwards, the extremity of the maxillary bone extending to the line of the anterior orbital border. The anterior insertion of the ventral is a little in advance of that of the dorsal fin. Interorbital region a little gently convex, with scattered tubercles. The pectoral fins reach the ventral, and the latter the anal.

Total length, .049; to opercular edge, .011; to line of first dorsal ray, .021; to do. of anal fin, .030; to base of caudal, .038.

Color like that of a young *C. analostana*, without spot on dorsal fin. Generally silvery, darker above, with an indistinct plumbeous lateral band. No distinct caudal spot. No spots on fins.

The pharyngeal teeth are, some of them, lost. They appear to have been 4–4. They have an obtuse grinding surface and no crenations.

TETRAGONOPTERUS ARGENTATUS Bd. and Gird.

Very abundant in the city of Monterey. The pectoral fins do not reach the ventrals, as they are said to do in the above-named species by Jordan (N. Am. Ichthyology, 255). In this respect, this species resembles the *T. brevimanus* of Günther, which appears to be very near to the *T. argentatus*, and to which my specimens may be referable. I am not, however, sure that the species are distinct.

HEROS CYANOGUTTATUS Bd. and Gird.

Very abundant in the city of Monterey, where it reaches seven inches and more in length. It is a good pan-fish, and is the Moharra of the people.

LEPOMIS HAPLOGNATHUS, sp. nov.

Scales 6–35—14–15; Radii; D. X–11; A. III–9. Inferior pharyngeal bones narrow, with conical teeth; gill-rakers obtuse, rather stout; no supplementary maxillary bone, nor palatine teeth.

Dorsal and ventral outlines subequally convex; form oval. Lower lip more prominent, maxillary bone reaching anterior line of orbit. The latter enters the head (without flap) three and a half times, and the nearly flat interorbital space once only. The depth enters the length, without caudal fin, two and three-fifth times, and the head (without flap) enters the same 3.25 times. The ventral fin barely reaches the anal. The extremities of the soft dorsal and anal are of the same length, and fall far short of the base of the caudal. The edge of the latter is notched at the middle, and the lobes are beveled at the free borders. The opercular flap is rather long. Six rows of scales on the cheek.

The color is olivaceous, yellowish below. A blue band crosses the preorbital bone above, and another follows the premaxillary border and passes along the inferior border of the orbit. Below this, another blue line crosses the cheek. Other blue bands have been obscured by the alcohol. Flap, plain black.

Total length, M. .113; to end of flap, .033; to line of anal fin, .054; to base of caudal fin, .091.

This species much resembles the common *L. pallidus* Mitch. of the United States. It has, however, about ten less scales in the lateral line, and the gill-rakers are rather short and quite obtuse. It is also allied to, but still more different from, the *L. humilis*.

This species is the most southern of the group to which it belongs, and, excepting the species of Micropterus, the first known from Mexican waters.

BATRACHIA.

RANA HALECINA Kalm.

REPTILIA.

PHRYNOSOMA CORNUTUM Harl.

The most southern locality for this species.

HOLBROOKIA TEXANA Trosch.

The most southern locality for this species.

SCELOPORUS TORQUATUS Wiegm.

This species is abundant at Monterey, and also at Laredo, on the Rio Grande.

SCELOPORUS VARIABILIS Wiegm.

The most northern locality for this species.

REMARKS.

In this small collection we have a mixture of the nearctic and neotropical faunæ. Among the fishes, well-known northern genera swim in the waters of Monterey with the two neotropical types Heros and Tetragonopterus. Two of the reptilian species are the common forms of Texas, while the *Sceloporus variabilis* is a species of the Tierra Caliente, which extends as far as Tehuantepec.

II. JALAPA, VERA CRUZ, Flohr.

The following species were presented to me by my friend Mr. Flohr, of the city of Mexico. Some of the species are rare or new.

EUMECES FURCIROSTRIS, sp. nov.

The characters of this species may be best understood by the following table of the Mexican and Central American species of this genus:

I. No nasofrenal plate.

a. Three supraorbital plates.

Frontal transversely divided; twenty-four rows of scales; a pale-bordered

black lateral band; three light stripes on head, the median bifurcating and joining the lateral ones on the muzzle.....*E. furcirostris* Cope.

Frontal not divided; twenty-four rows of scales; a brown lateral band, pale-bordered above, on head and neck. .....*E. dugési* Thominot.

aa. Four supraorbitals.

Rows of body scales in twenty-two to twenty-four rows; a lateral black band, pale-bordered above and below; head narrow.....*E. brevirostris* Günther.

Rows of body scales twenty-four; a dark, pale-bordered lateral band; a median band bifurcating on muzzle ....*E. lynxe* Wiegmann.

Rows of body scales twenty-eight; a dark lateral band; head wide; large .....*E. sumichrasti* Cope.

II. A nasofrenal plate.

Body scales in twenty-one rows; two median dorsal rows, wider; postmental not transversely divided.....*E. schwarzei* Fisch.

Body scales in twenty-eight rows; equal; postmental plate transversely divided.....*E. callicephalus* Boc.

When the limbs are appressed to the sides the feet are separated by the length of the posterior foot. Back brown. The lateral and median stripes are bordered with black from above the axillæ forwards. The black unites on the head, which is of that color above; below the lateral black it is yellow. Sides and lower surface of body and tail, blue.

Length of head and body to vent, M. .054; of head to auricular meatus, .009; width of head at do., .007. Length of posterior limb, .016; of anterior do., .011.

CELESTUS CHALYBÆUS Cope, Proceeds. Academy Philada., 1866, p. 321.

This species differs from the *C. steindachneri* Cope, in having two prefrenals, one above the other. There is but one, an elevated prefrenal, in the latter species. Both have two postnasals* one above the other. In *D. chalybæus* the limbs are shorter, not meeting when appressed, by the length of the hind leg. In *D. steindachneri* they are only separated by the length of the posterior foot. The latter species is well figured by Bocourt in the Miss. Sci. de Mexique.

Besides the specimen of the *D. chalybæus* from Jalapa, the Smithsonian Institution has received the type from Orizaba from Sumichrast, and a second specimen from West Tehuantepec from the same naturalist.

SCELOPORUS ÆNEUS Wiegm. Uniform leek green above. From the stomach of a *Eutænia scalaris*.

SCELOPORUS MICROLEPIDOTUS Wiegm. From the stomach of a *Crotalus triseriatus*.

CATOSTOMA SEMIDOLIATUM D. & B.

*In my diagnosis of the *C. steindachneri*, Proceeds. Acad. Phila., 1868, p. 123, the word postnasal is misprinted frontal.

EUTÆNIA SCALARIS Cope.

NINIA DIADEMATA Bd. Gird.

CROTALUS TRISERIATUS Wiegm. *Crotalus lugubris* Jan. For the character and synonymy of this species, see the third division of this paper.

III. NOTES ON CENTRAL AMERICAN AND MEXICAN BATRACHIA AND REPTILIA.

Cæciliidæ.

The species of this family, which have been described from the above region, are as follows. I now place them in the genera of this family as defined by Professor Peters in the Monatsberichte Akademie, Berlin, 1879, p. 930:

GYMNOPIS OLIGOZONA. *Siphonops oligozonus* Cope.

Hab.?

GYMNOPIS SIMA. *Siphonops simus* Cope.

Costa Rica, *Von Franzius.*

GYMNOPIS PROXIMA. *Siphonops proximus* Cope.

Costa Rica, *Gabb.*

GYMNOPIS MULTIPLICATA Peters.

Veragua

DERMOPHIS MEXICANUS. *Siphonops mexicanus* Dum. Bibr.

Tehuantepec, *Sumichrast;* Tobasco, *Laszlo.*

DERMOPHIS SYNTREMUS. *Siphonops syntremus* Cope. I refer this species here provisionally only, as I have not been able to find the type specimen.

Belize.

HERPELE OCHROCEPHALA. *Cœcilia ochrocephala* Cope.

Panama, *Gallær, Bransford.*

CÆCILIA ISTHMICA Cope.

East side of Darien, *Selfridge.*

Anguidæ.

BARISSIA FIMBRIATA Cope. *Gerrhonotus auritus* "Cope," Bocourt, Mission Scientif. Mexique, Reptiles, p. 337, Pl. xxi, fig. 2, xxi A, 7, 7a, not of Cope.

This species, which is handsomely figured by Bocourt, is not the species I described as *Gerrhonotus auritus,* but is a new species of Barissia. It agrees with the *B. antauges* Cope in having three pairs of supranasal plates instead of the two pairs of the other species. Its ear processes and other characters distinguish it from *B. antauges.*

Teidæ.

VERTICARIA HEDRACANTHA. *Amiva hedracantha* Bocourt, Miss. Sci. Mexique, Rept., p. 263.

The third species of this genus.

Colubridæ.

LEPTOGNATHUS TORQUATUS Cope. *Dipsadomorus fasciatus* Bocourt, Bulletin Soc. Philomathique, Paris, 1884, March; nec *Leptognathus fasciatus* s. *Tropidodipsas fasciata* Günther, 1868.

LEPTOGNATHUS SARTORII Cope, 1863. *Leptognathus sexscutatus* Bocourt, Bulletin Soc. Philomathique, Paris, 1884, March.

Hab: Guatemala, *Bocourt;* Vera Cruz, *Sartorius.*

MESOPELTIS MULTIFASCIATUS. *Leptognathus multifasciatus* Jan. M.S. Bocourt, Bullet. Soc. Philomathique, Paris, March, 1884. *Asthenognathus* Bocourt.

The genus Asthenognathus Boc., 1884, appears to be identical with Mesopetis Cope, 1866.

EUTÆNIA INSIGNIARUM, sp. nov.

Scales in twenty-one rows, all keeled except inferior row, which sometimes presents short keels at the bases of the scales. Superior labials eight, eye over fourth and fifth. Three postoculars. Temporals 1–2. Lateral band on the third and fourth rows of scales. No dorsal band, but the dorsal region yellower than the sides for a width of from four to six scales. A row of black spots above the lateral stripe, which are sometimes divided so as to form two rows one above the other. A row of incomplete black spots below the lateral line, which are formed by the adjacent black edges of three or four scales. A black spot on each side behind the angle of the mouth, which extend upwards to near the occipital shields, and is preceded by a light spot of half crescentic form. The last superior labial and temporals in front of this space, have black edges. Superior labials slightly black-edged. No spots on the parietal plates. Gastrosteges, 164; urosteges, 68 to 74. Total length of a rather small specimen, M. .435; of tail, .096; to canthus oris, .014.

I took the typical specimen of this species from a bunch of herbage which grew from the wall of the aqueduct at the castle of Chapultepec near the city of Mexico. Professor Herrera, director of the Escuela Preparatoria of the city of Mexico, showed me a living specimen which was taken near the city, and gave me a third, preserved in spirits. M. Bocourt sent a specimen to the Smithsonian Institution, and Dr. Dugés gave me a fifth, which was taken near Guanajuato.

This species is nearest to the *E. flavilabris.* I give comparative diagnoses of these two, together with that of a third species which is related to both, which I obtained on the upper waters of the Gila river in New Mexico.

First row of scales smooth or nearly so; tail shorter, urosteges, 68–74; no dorsal stripe nor occipital spots ..... *E. insigniarum.*

First row of scales smooth; tail shorter, urosteges 71; a dorsal stripe and occipital spots. ..... *E. flavilabris.*

First row of scales keeled; tail longer, one fourth of total, urosteges, 84; a dorsal stripe and occipital spots..... *E. megalops.**

EUTÆNIA CHRYSOCEPHALA, sp. nov.

The discrimination of this species will be facilitated by comparing it with other species of the genus, which occur in Mexico and Central America, in which the lateral stripe is on the second and third rows of scales.

I. Scales in seventeen rows.

Inferior row keeled; urosteges, 81; no dorsal stripe; a large black nuchal spot; head yellow. ..... *E. chrysocephala.*

II. Scales in nineteen rows.

Lower row of scales keeled; urosteges, 91; a dorsal stripe; lateral stripe not defined below; gastrosteges not black at the base; a large nuchal spot; head brown..... *E. collaris* Jan.

Lower row of scales smooth; urosteges, 67; a dorsal stripe; lateral stripe bordered below by a brown stripe; a black nuchal spot; head brown..... *E. pulchrilatus.*

Urosteges, 60–65; no stripes, but four rows of small spots which do not touch each other, but become larger on the neck; a large oblique black band on each side the nape; head brown; keels very strong... *E. sumichrasti.*

The *Eutænia cyrtopsis* of Kennicott belongs to this group, and comes nearest to the *E. collaris* Jan. In fact, the second variety of the *E. cyrtopsis*, described by Kennicott (Proc. Acad. Philada., 1860, p. 334), is the *E. collaris* Jan. The latter is a common species in Mexico. I have it from Guanajuato, *Dugès*, Orizaba, *Sumichrast;* from the valley of Toluca, *Vasquez*, and from Guatemala from *Dr. Van Patten.* I do not find the gastrostega to exceed 153 in number, while Kennicott gives 179 as the number in his types from Coahuila. I therefore keep the species apart, although I shall endeavor to verify the number given by Kennicott on his types.

The *E. chrysocephala* has a slender body, and a wide, flat head, with a large eye. The size of the latter contracts the frontal plate, so that it is not wider than the superciliaries posteriorly. The scuta are otherwise as usual. Superior labials eight, none higher than long, fourth and fifth below orbit. The inferior surfaces are darker than in *E. collaris*, which causes a better definition of the lateral line than in that species. There are representations of two rows of lateral black spots, but they are merely

* *Eutænia megalops* Kenn. Proceeds. Acad. Phila., 1860, p. 330. My specimen is from Duck creek, a tributary of the Gila. Gastrosteges 164; total length, M. .610; tail, .158. Color above brown, a few scales black-edged near the stripes. A postoral crescent, black-edged behind.

black scale-borders, those of the inferior row the more distinct. A similar row of black edges on the first row of scales. All of these spots become distinct on the sides of the neck. Nuchal spot large, black, and with a shallow notch behind; no occipital or other spots on the head. The gastrosteges have black bases, a character not seen in any of the other species here referred to.

Gastrosteges, 151. Total length, M. .430; of tail, .135, or one-third the total.

This handsome species was obtained at Orizaba, Vera Cruz, by Dr. Sumichrast.

EUTÆNIA PULCHRILATUS, sp. nov.

At first sight this species looks like the *E. flavilabris* Cope, but it has characters of the *E. collaris*, and adds some of its own.

The dorsal stripe, as in *E. collaris*, occupies but a single row of scales. The lateral stripe, occupies the adjacent edges of the second and third rows. The entire front row is covered by a broad brown band, which defines the lateral light band very distinctly below. This is not seen in either of the species above named. There are two rows of black spots between the dorsal and lateral bands, but the keels of all the scales involved in them are brown. There are no spots below the lateral light line, either on the neck or elsewhere. A large nuchal black spot, which is notched behind by the median band. No postoral crescent. Head above brown; lower surfaces uniform greenish, except tail, which is yellowish below. Occipital spots very indistinct.

The head is not very distinct from the neck. The frontal plate is wider than the supraorbitals. Gastrosteges, 158; urosteges, 67. Total length, M. .465; of tail, .105.

One specimen from Dr. Dugés; locality uncertain, but probably Guanajuato.

EUTÆNIA SUMICHRASTI Cope. Proceedings Acad. Philada., 1866, p. 306.

To the description already given, I add some notes taken from a third specimen. The frontal plate is wider than the supraorbitals. There are eight superior labials, and the orbit is bounded by the fourth and fifth. Temporals, 1–2; orbitals, 1–3. There is a trace of a dorsal stripe on the nape, which divides the nuchal spot in two. No postoral crescent. Below the square lateral spots on the sides of the neck is a row of smaller, alternating square spots, which serve to define a lateral stripe for a short distance. Superior labials brownish-yellow, brown edged. Inferior surfaces uniform dirty yellow.

The keels of the scales are very strong, except those of the first row, which are obsolete. Gastrosteges, 148; urosteges, 65. Total length, M. .265; length of tail, .065, or one-fourth the total.

The locality whence the typical specimens of this species were obtained is Orizaba, Vera Cruz. The locality of a third specimen is uncertain. It

may be the plateau of Costa Rico at Cartago, from Dr. Van Patten's collection. If this indication be correct, this is the most southern species of the genus.

STOREERIA TROPICA, sp. nov.

This species agrees with the *S. dekayi* Holbr., excepting in two points. It has but six superior labials. The diminution in the number is posterior to the orbit, and the fifth and sixth scuta are of a different form from those of the *S. dekayi*. They are longer and less elevated. The second character is in the color. This species lacks the dark mark that descends from the orbit to the superior labial margin in the *S. dekayi*.

Peten Guatemala, *H. Hague*.

COLUBER MUTABILIS, sp. nov. *Coluber triaspis* Cope, Proceeds. Amer. Philos, Soc., 1879, p. 271, nec Copei.

Two species of this genus are already known from Mexico, the *C. flavirufus* and *C. triaspis* Cope, which are distinguished by various peculiarities both of scutellation and of color. A considerable number of specimens have, however, been received by the Smithsonian Institution, which present intermediate characters. On study it appears that these really represent a species distinct from either, and one which inhabits the elevated regions of the country, while those previously known belong to the Tierra Caliente. I distinguish the species as follows:

Scales in 27–9 rows; one loreal; nine superior labials; three rows of temporal scuta between labials and occipital; dorsal and lateral spots large and close together; an oblique light band on post-temporal region, and a narrow yellow median spot on nape; marks not becoming obsolete ..... *C. flavirufus.*

Scales in 31–3 rows; one loreal; eight upper labials; three rows of temporal scuta; dorsal and lateral spots smaller, and separated; three longitudinal bands behind frontal region; all the markings becoming obsolete in a general brown color, with maturity ..... *C. mutabilis.*

Scales in 35 rows; two or three loreals; eight upper labials; four rows of temporals; dorsal and lateral spots smaller, separated; three longitudinal black bands from frontal region to nape; ? maturity. *C. triaspis.*

Of the *Coluber mutabilis* I have before me four specimens from Vera Paz from Mr. Hague; one from the plateau of Costa Rica from Mr. Zeledon, and one from the central or elevated part of the State of Tehuantepec, from Mr. Sumichrast. I have examined a seventh specimen in the collection of Professor Alfredo Dugés, who took it in the State of Guanajuato. Of the *C. flavirufus*, there are three specimens before me; the type from Tobasco, *Berendt;* one from Vera Cruz from Sartorius, and one from Yucatan from the Schott collection of the Commision Cientifica. I have examined two large specimens in the city of Mexico brought from the State of Chiapas, from Dr. R. Montes-de-Oca.

Slight variations sometimes occur in the *C. mutabilis*. One specimen has 35 rows of scales; another has but two rows of temporals on one side; another has nine superior labials on one side.

The head is long and rather narrow. The prefrontals are, each, longer than wide; the frontal is not narrowed; the parietals are truncate behind. The suture between the loreal and the prefron tal is oblique, running posteriorly downwards, so that its superior border is only half as long as the inferior. The preocular does not reach the frontal. There are, as in the other Mexican species of the genus, but two postoculars. The eye is over the fourth and fifth labial. None of the labials behind the fifth is elevated, but the sixth is elongate so as to border the ends of the three long temporal scuta. The inferior of these covers the seventh and part of the eighth labials, and supports above it two others like it, all being directed downwards and forwards. The superior encloses little scale with the superior postocular. Inferior labials, eleven; gencials well developed, the posterior smaller and separated by scales.

In a young specimen 450 mm. in length, where the color markings have not become obsolete, there are 76 dorsal spots, of which 51 are between the nape and the vent. These spots are transversely quadrate, covering 11 scales transversely, and two and a half scales anteroposteriorly. They are dark brown with light edges, and paler centers. The interspaces are less than two scales long. The lateral spots are opposite the intervals and are in one row; they are subround or suboval. There are two brown stripes on the nape which, instead of uniting at both ends, as is the case in the *C. flavirufus*, are separate posteriorly and diverge anteriorly, extending to above the posterior part of the orbits. Between them another band occupies the middle line, but is more or less broken. A broad brown band convex forwards between the fronts of the orbits. A brown spot behind orbit. Below immaculate.

Gastrosteges, 282; anal double; urosteges, 109. Total length, M. 1.090; of tail, .235 mm.

The typical specimen is from Vera Paz; No. 6735 Mus. Smithsonian.

MANOLEPIS NASUTUS. *Tomodon nasutus* Cope, Proceedings Academy Philadelphia, 1864, p. 166.

This species cannot enter Tomodon D. & B., because it has a divided anal plate, and no scale-fossæ, though it agrees with that genus in its single nasal plate and smooth scales. I therefore propose the genus Manolepis to embrace it and similar species.

HYDROCALAMUS QUINQUEVITTATUS. *Homalopsis quinquevittatus* Dum. Bibr. Erp. Gen. vii, p. 975. *Calopisma quinquevittatus* Jan. Elencos Sistematico, p. 75. *Hydrops lubricus* Cope. Proceeds. Acad. Phila., 1871, p. 217.

Vera Paz, *Dum. Bibr.*; E. Tehuantepec, *Streets.*

Duméril and Bibron put this species quite out of its place, so that I did not perceive it in my *Hydrops lubricus*. It requires a new generic desig-

nation, which I give above. It is allied to Dimades, Abastor, etc., but differs from them all in having a grooved posterior maxillary tooth. The characters of the genus Hydrocalamus are:

Opisthoglyph. Two internasal and two prefrontal plates. Two nasals, a loreal, and one preocular. Anal scutum divided. Scales smooth.

The genus differs from the nearest opisthoglyph calamarians as follows: From Elapomorphus and Scolecophis in the divided anal scutum, and from the former in its two nasals: from Procinura in the absence of the rugosities of the caudal scales.

LIMNOPHIS SEPTEMVITTATUS. *Calopisma septemvittata* Fischer, Verhandl. Naturwiss. Verein, Hamburg, 1879, p. 84, Pl. i, f. 3.

This species agrees exactly with Limnophis Günther in scutellation, and approaches very nearly in dentition. It is not referable to any other genus now named.

TRIMETOPON GRACILE. *Ablabes gracilis* Günther. Ann. Magaz. Nat. Hist., 1872, p. 18. From Costa Rica, Günther.

The characters of the genus Trimetopon are as follows:

Two internasals; one prefrontal plate. Two nasals; rostral not produced; a loreal and one preocular. Scales smooth, with one pore. Anal divided.

There are three other aglyphodont calamariform genera, with one prefrontal plate. From Colorhogia Cope, Trimetopon differs in having two nasal plates; from Opisthotropis Günth., in having smooth scales; and from Chersodromus R. & L., in the presence of a preocular plate, and in the smooth scales.

GYALOPIUM PUBLIUM Cope. American Naturalist, 1884, p. 163. *Ficimia publia* Cope, Proceeds. Acad. Phila., 1866, p. 126. *Ficimia ornata* Bocourt, Miss. Sci. Mexique, 571, Pl. xxv, f. 10.

Hab. Yucatan, *Schott.*

GEAGRAS REDIMITUS Cope. Journal Acad. Philada., 1875, p. 141. *Sphenocalamus lineolatus* Fischer, Oster Programm des Akad. Gymnas., Hamburg, 1883, p. 5, Pl. i, figs. 3–5.

Tehuantepec, *Sumichrast;* Mazatlan, *Fischer.*

GEAGRAS FRONTALIS Cope. Journal Academy Philada., 1875, p. 142. *Toluca frontalis* Cope. Proceeds. Acad. Phila., 1864, p. 147. *Pseudoficimia pulchra* Bocourt. Miss. Sci. Mexique, 572, Pl. xxxv, f. 12.

Colima, *Xantus;* Guadalaxara, *Major.*

GEAGRAS SUMICHRASTI Bocourt. Cope, Amer. Naturalist, 1884, p. 162. *Enulius sumichrasti* Bocourt. Miss. Sci. Mexique, 538, Pl. xxxi, f. 6.

W. Tehuantepec, *Sumichrast.*

GEAGRAS LONGICAUDATUS Cope. Amer. Naturalist, 1884, p. 162. *Enulius murinus* Cope, Bocourt, Miss. Sci. Mexique, p. 537, Pl. xxxv, f. 9, nec Copei.

West Tehuantepec, *Sumichrast.*

PROC. AMER. PHILOS. SOC. XXII. 118. W. PRINTED MARCH 7, 1885.

LEPTOCALAMUS UNICOLOR. *Geophis unicolor* Fischer. Abhandl. d. Naturwiss. Vereins, Bremen, 1881, p. 227.

This species is allied to those of the genus Catostoma, but Fischer remarks that it has an elongate posterior maxillary tooth, or a syncranterian dentition. This requires its separation from Catostoma, and its location in another genus, as indeed is remarked by Fischer, *l. c.* This has been already established by Günther for another species.

RHEGNOPS ZEBRINUS Jan. *Rhabdosoma zebrinus* Jan Bocourt, Miss. Scient. Mexique, Pl. xxxiv, fig. 1.

This and another species are separated by Bocourt from the genus Catostoma (*Geophis*) on account of the divided anal scutum. He applies to this genus the name Rhabdosoma Dum. Bibr. Unfortunately there is not a species of that genus, as enumerated by Duméril and Bibron, which possesses this kind of an anal scutum, and they must all be referred to Catostoma, of which the name Rhabdosoma is a synonym. Meanwhile in the year 1866,* I proposed for a species having the characters of Bocourt's Rhabdosoma, the name Rhegnops. This genus differs from Carphophiops in the two nasal plates, and the single pair of genecials. The type is *R. visoninus* Cope, *l. c.*, from Honduras.

CONTIA MICHOACANENSIS Dugés MS.

Muzzle moderately prominent, rounded; eye moderate; body cylindric; tail short, acute at end, not slender. Scales without fossæ.

Rostral plate much wider than high. Internasal small. Frontal large, longer than wide, posterior angle obtuse. Superciliaries moderate, much narrowed anteriorly. Parietals as long as the frontal, rounded posteriorly. The single nasal is narrow and is obliquely placed, being in contact by its posterior border with both the prefrontal and loreal, and not touching the second superior labial. Loreal longer than high. Preocular touching prefrontal and third superior labial. Two postocular, the inferior resting on the fourth and fifth superior labials. Temporals 1–2. Seven superior labials, the third and fourth entering the orbit, the sixth very small. Six inferior labials, of which four are in contact with the genecials; postgenecials one-third the length of the pregenecials. Between the former and the gastrosteges, seven rows of small scales. Scales in fifteen rows. Gastrosteges, 152; anal divided; urosteges, 37.

Length of head and body, M. 0.160; of tail, .035; diameter at middle of body, .005.

Ground color probably red in life; in alcohol it is a clear yellow. A large black spot covers the frontal, and the superciliaries, less their anterior extremities, surrounds the eye, and terminates on the loreal, and the corresponding superior labials. It extends also on the antero-internal angles of the parietals. Another black spot forms a wide collar interrupted on the median line below. Then follow thirteen transverse rings, each oc-

* Proceeds. Academy, Philada., p. 128.

cupying five or six rows of scales on the back, narrowing below, where some of them are interrupted. Two of the rings are so wide as to lead to the belief that each of them consists of two rings united, so that the whole number is sixteen. Tail unspotted. The third, fifth, seventh and ninth interspaces from the head have the scales black-tipped, and are wider than the black bands. The skin has an elegant clear blue reflection.

From the state of Michoacan, Dr. A. Dugés.

Crotalidæ.

CROTALUS POLYSTICTUS Cope. Proceeds. Acad. Philada., 1865, p. 191. *Crotalus triseriatus* Wagl. Jan Iconographie des Ophidiens, nec Wagleri. *Crotalus ximenesii* Dugés, Naturaleza, Mexico, 1877, p. 23, pl. i, figs. 18–20.

Table land of Mexico.

I give the comparative characters of this species, and of the allied *C. triseriatus* of Wiegmann. I think that Professor Jan has transposed the name of that species to this one. I took a full description of the Crotali in the museum of Munich, from which apparently Wagler drew up his description (Naturliches Syst. d. Amphibien, 1830, p. 176), and none of them belong to the present species. My notes made in Berlin, which I visited immediately afterwards, state that the specimens labeled *C. triseriatus* in the museum of the University, where Wiegmann worked, are like those of Munich.

The *C. triseriatus* varies more than the *C. polystictus*. My descriptions are drawn up from five specimens of the latter, and six specimens of the former.

Two loreal plates, one above the other. Four internasals and four prefrontals, all longer than wide; three rows of interorbital scuta and scales. Infraorbital scales in two rows of equal size. Four elongate distinct brown spots behind occipital region; a narrow yellow band across frontal region. A large brown spot below orbit, and one below maxillary fossa. Five rows of *large* dorsal spots. Scales in twenty-seven rows; labial scuta fourteen; subcaudal scutella 18 and 19. Generally of larger size.

One of the five specimens above mentioned has twenty-five rows of scales.

The specimens all come either from Guanajuato (Dugés), or from the valley of Mexico (Herrera).

CROTALUS TRISERIATUS. *Uropsophus triseriatus* Wiegm. Wagler Nat. Syst. Amphib., 1830, p. 176. *Crotalus lugubris* Jan. Prodrome d'un Iconogr. Revue et Mag. de Zoölogie, 1859, p. 31, Pl. E. Dugés' Naturaleza, Mexico, 1877, p. 25.

One loreal plate; two internasals and four prefrontals, wider than long, or the latter, square. Three or four rows of interorbital plates and scales. Two rows of infraorbital scales, of which the superior is very small. Colors plainer. Two post-occipital spots; no frontal band; no infra-

orbital or infrafossal spots. One row of *large* dorsal spots. Twenty-three rows of scales; superior labial scuta 11–12; subcaudal scutella 22–29.

There are usually two rows of small spots on each side of the large dorsal series, and sometimes the latter breaks more or less into two rows. In a specimen from Guanajuato (Dugés), the dorsal spots continue into the small lateral spots, forming lateral cross-bands as in *Crotalus enyo*. In a specimen from the valley of Toluca, the lateral spots are obsolete, and there are 25 rows of scales. The anterior part of the superior preocular is cut off to form a second loreal behind the usual one.

The *Crotalus intermedius* of Fischer is near this species, but has several peculiarities according to Fischer, which may distinguish it.

Hab. Guanajuato, Dugés; Jalapa, *Flohr;* Toluca, *Vasquez.*

CROTALUS BASILISCUS Cope. Proceeds. Academy Phila., 1864, p. 66. *Crotalus rhombifer* Latreille, Dugés La Naturaleza, Mexico, 1877, p. 22.

This species, originally discovered by Xantus at Colima, is generally distributed in Mexico. I have not seen it from east of the plateau. Dugés has obtained it at Guanajuato.

IV. ARUBA, LEEWARD ISLANDS; Julien.

The present collection was made by Prof. A. A. Julien, of Columbia College, New York. Aruba is the westernmost of the series of islands which lie in the Caribbean sea along the north coast of South America. Its position is but a short distance to the eastward of the mouth of the Gulf of Venezuela. Its position gives its fauna considerable interest. The birds brought by Professor Julien, have been already reported on in papers published by the New York Academy of Sciences, by my friend, George N. Lawrence.

1. PALUDICOLA BRACHYOPS Cope.
2. GONIODACTYLUS ALBOGULARIS D. & B.
3. GONIODACTYLUS VITTATUS Wiegm.
4. PHYLLODACTYLUS JULIENI, sp. nov.

This species is nearly related to the *P. tuberculosus* Wiegm., but may be distinguished by three characters. First, the abdominal scuta are less numerous, forming about thirty transverse series between axilla and groin; while those of *P. tuberculosus* are in at least forty cross-rows. Second, the dorsal tubercles form uninterrupted longitudinal series, no small scales intervening between those of one row; although small scales separate those of different rows. Third, there are three scuta behind the mental. In most specimens of the *P. tuberculosus* there are two; in one only I find three. There are five narrow, straight blackish cross-bands between the axilla and groin; one in the front of the arms, and one across the nape, a brown band posterior to the eye. These markings become obsolete in the

largest specimens. The legs are light brown with pale spots, marks which are most distinct in adults. When the limbs are appressed to the side, the elbow marks the middle of the longest posterior toes.

The characters of this species may be well understood by comparing it with other species of the genus as follows:

I. Tubercles larger and more numerous, keeled.

Abdominal scales in 30 transverse and 17 longitudinal rows; two postmentals and four scales behind them .....*P. ventralis* O'Sh.

Longitudinal series uninterrupted; abdominal scales in 30 transverse, and 21 longitudinal rows; 3 postmentals and six scales in the row behind them .....*P. julieni* Cope.

Longitudinal series interrupted by scales; abdominal scales in 40 transverse and 25 longitudinal rows.....*P. tuberculosus* Wieg.

II. Tubercles fewer, smaller and not keeled.

Tubercles in rows; abdominal scales in 56 rows; three postmental scuta; discs larger..... .....*P. galapagoënsis* Pet.

Tubercles in rows; abdominal scuta in 56 rows; four postmentals; discs very small..... .....*P. microphyllus* Cope.

Tubercles not in rows, more obscure; abdominal scuta in 50 rows; two or three postmentals; discs larger; cross-banded.....*P. inæqualis* Cope.

The abnominal scales are in more numerous longitudinal rows than described in the allied *P. ventralis* O'Shaughnessy* of Jamaica, and the postmental plates and scutes have quite a different arrangement. The six scales of the first row form a series very convex backwards. Several specimens.

THECADACTYLUS RAPICAUDA Houtt.

TRETIOSCINCUS BIFASCIATUS Dum.

CNEMIDOPHORUS MURINUS D. & B.

AMIVA BIFRONTATA Cope. This species is now well known to be a New Grenadian species, and not to be found in the Virgin islands as was originally suspected.

IGUANA TUBERCULATA Laur.

ANOLIS LINEATUS Daudin. Two specimens which only differ from the description of Duméril and Bibron in having the muzzle a little longer or the nostril a little posterior. The latter is separated from the rostral plate by two scales, instead of one, as described by Duméril and Bibron. These authors give Martinique as the habitat as indicated by a label.

V. CURACAO; U. S. Fish Commission.

A jar of reptiles from the above island, obtained by the naturalists of the U. S. Fish Commission, was submitted to me by Professor S. F. Baird, director. Curacao, as is known, is one of the same group as Aruba, and

*Annals and Mag. Nat. His., Oct., 1875.

the determination of its fauna is a point of considerable interest. Unfortunately the number of species taken is small. The names are as follows:

CNEMIDOPHORUS MURINUS D. and B. Specimens as large as the *Amiva surinamensis*, No. 13,860.

GONIODACTYLUS ALBOGULARIS D. and B. No. 13,859.

Var. I. Four specimens. A pale dorsal band bounded on each side with a row of brown spots; two rows of blackish spots on each side; belly unspotted; throat faintly lined.

Var. II. One specimen. Brown above with a blackish collar pale edged behind, which sends forwards a brown band to the eye. Above this a short brown band from eye. Lips and throat with some brown speckles.

Var. III. One specimen. Brown above; a blue-black band along lips to shoulder. A short blue-black inguinal longitudinal band; below dusky, except throat, which is very pale, but with faint lines spreading on each side from a pale median band.

VI. NICARAGUA; Moser.

A small collection was sent to the National Museum by Lieut. J. F. Moser, U. S. N. It contains the following species:

DENDROBATES TINCTORIUS Schneid. No. 13,736.

DENDROBATES TYPOGRAPHUS Keferst. No. 13,738.

AGALYCHNIS HELENÆ Cope, sp. nov.

Head large and wide, muzzle short. Long diameter of eye a little less than length of muzzle in front of it measured obliquely, or one-third longer than muzzle measured axially, and entering width between anterior canthi of eyes one and one-half times. Nostril nearly terminal; canthus nostralis distinct concave. The tympanic membrane is not distinct, and is a sub-vertical oval, two-thirds the long diameter of the eye. Inferior palpebra with oblique sub-parallel white veins. The vomerine teeth are in short series directed inwards and backwards from the anterior inner angle of the large choanæ. Ostia pharyngea half as large as choanæ. Tongue large, wide and openly emarginate behind. The inner toes of both anterior and posterior feet are not opposable, and are furnished with well developed discs. Both are shorter than the adjacent second digit respectively. The fingers are one-fourth webbed, and the toes one-third webbed. The heel of the extended leg reaches the end of the muzzle; the closed leg marks the end of the third toe with the knee. The width at the sacrum is but a little more than half that of the head posteriorly. Skin smooth above everywhere. Length of head and body, M. .030; width of head posteriorly, .0115. Length of extended fore limb, .018; of extended hind limb, .042. Of the latter, the foot measures .0175, of which the tarsus is .0085.

The heel and the elbow present a dermal thickening at the apex; the inside of the elbow joint is also shortly webbed.

The color in spirits is greenish cream color; probably representing green, yellow and purplish in life. The same color covers the external faces of

fore-arm, tibia, tarsus, and fifth posterior toe, and a narrow band on the upper surface of the femur. The humerus, with the concealed surfaces of the limbs, and a well defined band from axilla to groin are dark purplish, which is only interrupted by five vertical narrow yellow bands, which cross the lateral band, and join a yellow border which bounds its superior edge. Toes and lower surfaces, yellow, deeper on the abdomen.

This very pretty tree frog is most nearly allied to the *Agalychnis callidryas* Cope, a species which has been found both in Panama and in Vera Cruz. It differs in the dark color of the concealed surfaces, and in the shorter, wider head, and in the smaller tympanic membrane. No. 13,737.

HYLA PUMA, sp. nov. Size of *H. carolinensis*.

Fingers with rudiment of web between external digits; toes half webbed. Vomerine teeth in transverse patches, whose edges are in line of the posterior border of the posterior nares, Ostia pharyngea one-third as large as choanæ. Tongue subround, nearly entire. Tympanic membrane distinct, an oblique oval, its long diameter two-thirds that of eye fissure. Canthus rostralis well marked, concave; nostril nearly terminal, separated from orbit by a space equal long diameter of tympanum. Heel reaching middle of lores. Head rather small, muzzle short. Belly areolate, all superior surfaces smooth. Digital dilatations equal half diameter of tympanic disc. Color, above, uniform dark brown; below, uniform light brown.

Total length, M. .045; of head from posterior line of tympana, axial, .015; width of do. at posterior line of tympana, .018; length of posterior limb, .071; of posterior foot, .031; of tarsus, .017; of anterior limb, .028; of anterior foot, .013.

This species is near to the *H. phæota* Cope of the Darien region, and the *H. pulchella* D. and B. of Southern Brazil. In the former the head is larger in proportion to the body, and the hind limbs are rather longer. The color includes cross-bands on back and limbs, and posterior to eye, all of which are wanting from *H. puma*. The *H. pulchella* has much the same proportions, etc., but has longer hind limbs, and a different coloration, especially a very distinct lateral band. No. 18,735. One specimen.

CORYTHOPHANES MEXICANUS Wagler. No. 13,745.

ANOLIS BRANSFORDI Cope. Proceeds. Academy Phila., 1874, 67. No. 13,739.

PLIOCERCUS DIMIDIATUS Cope. A specimen with seventeen black annuli on the body, with the scales of the light interspaces black-tipped. In the type there are fourteen annuli, and the light-colored scales are not black-tipped. No. 13,741.

DRYMOBIUS BODDÆRTI Seetzen. No. 13,743.

TRETANORHINUS NIGROLUTEUS Cope. No. 13,744.

The nasal plates of this specimen do not meet in front of the internasals as described in the type specimen; otherwise they agree.

BOTHRIOPSIS BRACHYSTOMA Cope. No. 13,742.

VII. Upper Beni River, Bolivia; Heath.

The collection described below, was made by Dr. Edwin R. Heath during his explorations of the Upper Beni river in Bolivia. The country through which Mr. Heath passed had not been previously examined by any naturalist, hence considerable interest attaches to this collection.

Dermophis crassus, sp. nov.

The most robust species of the genus. Tentacular fossa near to but distinct from the eye, half way between canthus oris and nostril. Annuli 95, all complete except the first, which is not complete above; the third and fourth not complete below; and 94th and 95th, which are incomplete above. General form depressed. Width of head at first fold, equal length from same point. Length, mm. 423; width, 23 mm. or $\frac{1}{18\frac{1}{4}}$. Color black above and below; the plicæ when opened, white within.

The number of plicæ is smaller than in any other species, and the form is more robust. Two specimens, besides a third from Eastern Peru, obtained by Professor Jas. Orton.

Mabuia agilis Raddi.

Diploglossus fasciatus Fitz.

Amphisbæna beniënsis, sp. nov.

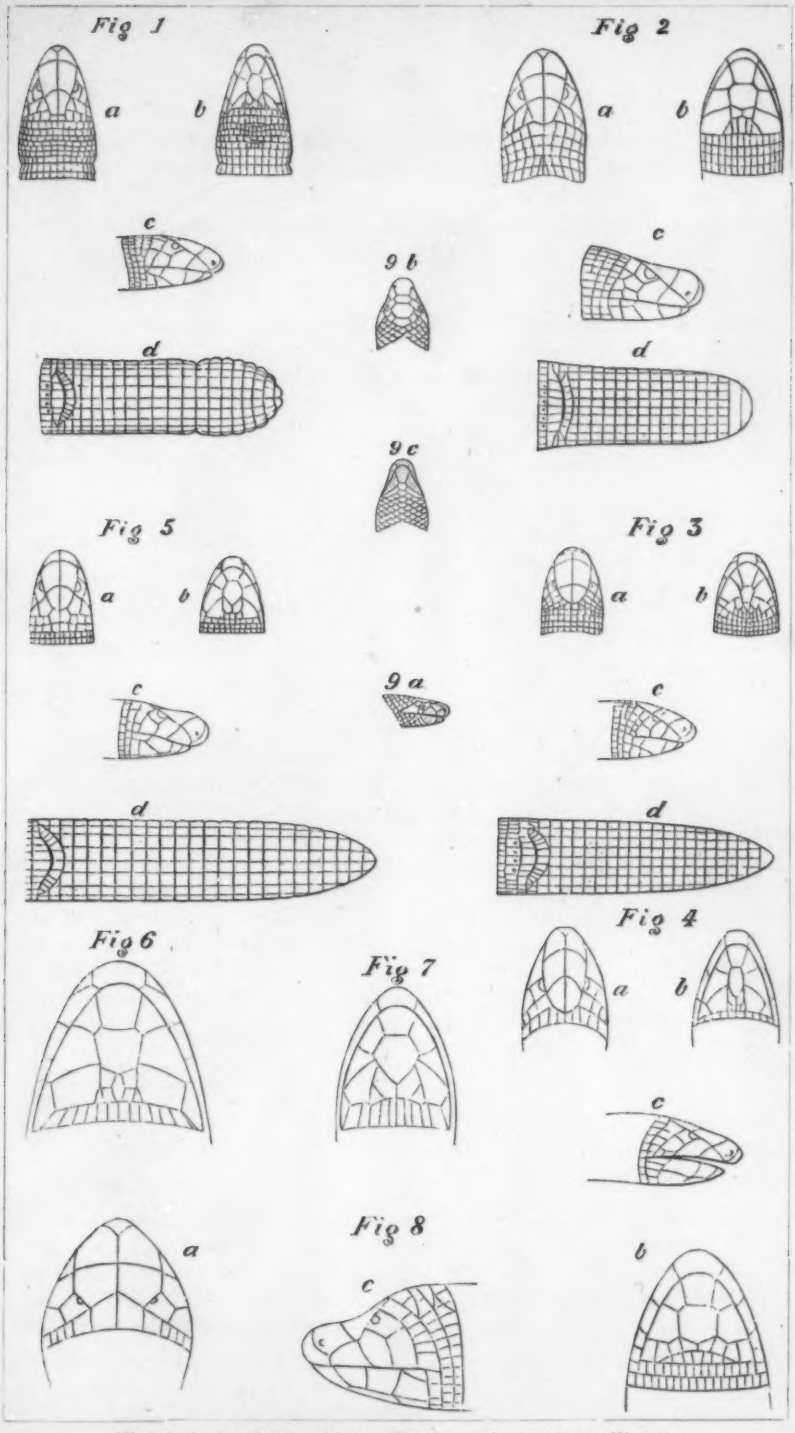
Of the group to which *A. pretrei*, *A. vermicularis*, *A. angustifrons* and *A. occidentalis* belong. Muzzle moderately elongate, obtuse; rostral plate a little visible from above. Nasofrontals broader than long, with nearly straight borders. Prefrontals longer than wide, with the posterior angle a little less than right. Frontals small; forming together a pentagon, each bounded posteriorly by a single small square parietal. One diamond-shaped ocular, showing the eye indistinctly in its anterior angle. Labials $\frac{4}{4}$; the last one above and last two below, small; the latter pair not strongly separated. First superior labial longer than high; second higher than long; third longer than high, and separated from the ocular by a larger scute. Symphyseal scute subquadrate and truncate behind, bounded laterally by the first inferior labial only. Postsymphyseal nearly square, bounded laterally by the second inferior labial only. It is followed by two square scuta, each of which is bounded laterally by a large plate, which bounds the third inferior labial below.

Tail with sixteen annuli; preanal plates eight, or if the full extent of the fissure be considered, by ten plates. Preanal pores six. Total length 335 mm.; of head to canthus oris, .012; of tail, .025 M. Color above, light reddish brown; below yellow.

The scutellation of the head of this species distinguishes it from all the species named. The tail is as short as in the *A. angustifrons* Cope (Proceed. Acad. Philada., 1861, p. 76). See below, in synopsis of Amphisbæna.

Aporophis conirostris Günth.

A variety in which the dark, transverse dorsal marks are interrupted on



Figs. 1—8, Amphisbænidæ. Fig. 9, Anelytropsis papillosus.

the middle line, and are not always continuous, and are pale-bordered in front, and with a series of black spots below the lateral pale band. The light color below is red in life.

OPHROMORPHUS MELEAGRIS Shaw *var.* SEMILINEATUS Cope. Proc. Acad. Phila., 1860, 252. *Liophis meremmii* D. & B., var.

OPHEOMORPHUS TYPHLUS Linn.

CYCLAGRAS GIGAS D. and B.; *Xenodon gigas* Dum. Bibr.; *Lejosophis gigas* Jan.

This species, with the *Liophis bicinctus* Dum. Bibr., belongs to a genus distinct from both Liophis and Xenodon. Its characters are: Dentition diacranterian; anal acute, entire; a circle of scales, with the superciliary surrounding the eye; scales smooth. Professor Jan has already distinguished the genus, but has given it a name (Lejosophis) which, when properly spelled (Liophis), is one which has already been used. I, therefore, give it another name, as above.

XENODON SEVERUS L.

OXYRRHOPUS SEBÆ D. & B.

PHILODRYAS VIRIDISSIMUS L.

LEPTOPHIS MARGINATUS Cope.

VIII. RIO GRANDE DO SUL, BRAZIL; H. Smith.

The Naturalist Brazilian Exploring Expedition, under the direction of Mr. Herbert H. Smith, commenced its work in the province of Rio Grande do Sul. The principal collections were made at Sao Joao do Monte Negro. The present catalogue shows that the snake-fauna is not poor, and it adds some important points in the history of the geographical distribution of the Batrachia and Reptilia of South America. A number of the species in the collection are sent for the first time to the United States.

BATRACHIA.

BUFO DORBIGNYI Dum. Bibr.

BUFO MARINUS Linn.

ENGYSTOMA OVALE Schneid.

HYLA VAUTERII Dum. Bibr.

HYLA PULCHELLA Dum. Bibr.

The normal coloration is presented by numerous specimens. Another one is brown, with three darker, brown dorsal bands, a median narrow one and two lateral wider ones, with indistinct superior margins above the light border of the lateral brown band. The hind-legs are also cross-banded, a character not found in the normal form.

PROC. AMER. PHILOS. SOC. XXII. 118. X. PRINTED MARCH 9, 1885.

PALUDICOLA RANINA, sp. nov.

Metatarsal tubercles, two; minute. A subround inguinal gland. Skin of back with delicate folds, viz., a straight dorsolateral and a median pair, which approach each other above the scapulæ, then diverge, then approach in front of the sacrum, and then diverge and disappear. Numerous short plicæ and narrow warts on each side of the coccyx; superior surfaces of posterior legs with smaller warts. Toes slender, free, with narrow dermal margins. Abdomen with a circular fold. Form of head and body rather elongate, legs not long, feet long; heel of extended hind leg reaching to middle of orbit. Tympanic disc faint or invisible, forming a vertical oval, whose long diameter is a little more than half that of the eye-fissure. The muzzle is acuminate, and is a little longer than the long diameter of the eye. The profile descends to the end of the muzzle, which is narrowed, but not prominent. Nostrils nearly terminal. Tongue pyriform, entire. When the fore limb is extended, the wrist reaches the end of the muzzle. First finger shorter than second; third quite long.

Length of head and body, M. .028; of head to posterior line of tympana, .009; width of head at the same, .0095; length of fore limb, .018; of fore-foot, .008; of hind limb, .045; of hind foot, .017.

The color varies from brown to gray above. A black band passes from the orbit to the level of the abdomen, its abdominal border extending from the axilla three-quarters way to groin. A black line on inferior edge of canthus rostralis. Lip from this band to the postorbital band, with numerous light-brown striæ extending downwards and backwards. Inguinal gland with a round black spot, with some pale-brown lines concentric to it in front and below. A brown band between superciliary edges, and a T-shaped brown mark on top of muzzle. Middle line between dermal plicæ brown, generally with a pale brown spot at their point of expansion. A light-brown band extends from this brown space posteriorly and downwards on each side. Other brown shades on the lateral dorsal region. In some of the specimens some of these markings of the upper surfaces are wanting. Below straw color, thickly speckled with reddish-brown everywhere, excepting on the posterior abdominal and subanal regions. Legs with brown cross-band, with narrow pale edges, two on the tibia, very oblique. Concealed posterior face of femur, brown with pale speckles.

This species is apparently abundant at Sao Joao do Rio Negro. The smaller specimens are often darker colored, have more numerous dorsal plicæ, and have four dorsal, brown, longitudinal bands. It agrees with the genus Paludicola as I have defined it (under the name of Gomphobates R. & L), in the absence of frontoparietal fontanelle, the non-union of the prefrontal bones, and the osseous xiphisternum with narrow bifurcate cartilage.

In my estimation, Mr. Boulenger has united two, and perhaps four, genera, in his revision of Paludicola (Catal. Batr. Salientia, Brit. Mus., 1882, p. 229). I have distinguished these genera as follows:

I. A frontoparietal fontanelle.

Inguinal glands.....*Pleurodema.*
No inguinal glands.....*Liuperus.*

II. Frontoparietal bones ossified.

Inguinal glands.....*Paludicola.*

M. Boulenger has shown that the genera established on the degree of development of the metatarsal shovels are not tenable.

LEPTODACTYLUS OCELLATUS Linn.

LEPTODACTYLUS MYSTACINUS Burm.

PSEUDIS PARADOXA Laur.

Reptilia.

ANOPS KINGII Bell.

The genera of the Amphisbaenidæ, besides the Lepidosterninæ, are the following, as they appear to me:

I. The nasal plates lateral, separated from each other on the median line.

a. Nasals separated by the rostral.

Rostral with a median cutting edge, extending between the frontonasals; *Anops* Bell.
Rostral flat, not extending between frontonasals.....*Diphalus** Cope.

aa. Nasals separated by the frontonasals.

Frontonasals united into one plate; no frontals.....*Blanus* Wagl.
Frontonasals united; frontals present.....*Cadea* Gray.

II. The nasal plates in contact with each other on the median line.

a. Preanal pores present.

Nasal plates distinct.....*Amphisbæna* Linn.
"Nasal plates united." Gray.....*Typhloblanus* Fitz.
Nasals, frontonasals and anterior labials united.....*Ophioproctes* Boul.

aa. No preanal pores.

Nasal plates distinct.....*Aporarchus* Cope.

AMPHISBÆNA TRACHURA, sp. nov.

Before giving the detailed characters of this species, I will compare all the true Amphisbænæ of which I can obtain information. With extended explorations this number has so increased, that new definitions are needed.

I. No supraorbital plates (*Amphisbæna*).

A. A preorbital plate.

A suborbital plate; caudal rings 26; anal pores 8. *A. subocularis* Peters.
A suborbital; caudal rings 24; anal pores 4.....*A. mildei* Peters.
No suborbital plate; 4 superior labials, last largest; 3 inferiors, first very large; a large temporal on each side.....*A. kraussi* Peters.

* Type *Diphalus fenestratus* Cope. Proc. Acad. Phila., 1861, p. 76; *Amphisbæna antillensis* R. & L.

AA. No preorbital plate.

a. No suborbital plate.

β. Symphyseal plates wide as, or wider than long.

Four superior labials; caudal rings 17 ..... *A. alba* L.

ββ. Symphyseal plate longer than wide.

Superior labials 4; head short, wide; tail smooth; above spotted yellow and brown ..... *A. occidentalis* Cope.

Superior labials 3; head acute; tail smooth; uniform above.

A. darwini D. & B.

Superior labials 3; head acute; tail conical, with 18 rings; several terminal rings very distinct and divided into prominent hard tubercles; color uniform above ..... *A. trachura* Cope.

aa. A suborbital plate.

β. Two small labials below suborbital.

Four superior labials; symphyseal and postsymphyseal narrow; caudal rings 17, smooth ..... *A. angustifrons* Cope.

ββ. One large labial below suborbital.

Superior labials 4; tail smooth, with sixteen rings; symphyseal and postsymphyseal plates square; unicolor above ..... *A. beniensis* Cope.

Superior labials 3; tail smooth with 26–8 annuli; unicolor above.

A. pretrei D. & B.

aaa. Two suborbital plates.

Superior labials 3; symphyseal and postsymphyseal plates square; tail with 29–33 smooth annuli; spotted above ..... *A. fuliginosa* Linn.

II. A supraorbital plate; two frontonasals.

a. No preorbital (*Zygaspis* Cope).

Several pairs of parietals and temporals; inferior labials 4.

A. quadrifrons Peters.

III. A supraorbital and preorbital plates; frontonasals united.

Cynisca Gray.

One pair of parietals and temporals; inferior labials 3. . *A. leucura* D. & B.

The *Amphisbæna vermicularis* D. & B. probably enters the above synopsis near to the *A. darwini*, but I cannot learn all of its characters. It is distinct from all the species of Division I, in having a more slender body with more numerous annuli, viz., 232, according to Duméril and Bibron. I cannot now give the characters of the *A. camura* Cope, as the specimens are mislaid.

In general appearance the *Amphisbæna trachura* is a good deal like the *A. pretrei* as figured in the zoölogy of Castelnau's journey in South America. It also resembles in general the *A. angustifrons* from Buenos Ayres. The head is elongate and the muzzle decurved and prominent. The rostral plate is just visible from above. The frontonasals are each longer than wide. The frontals form an oval which is just as wide as long. The third superior labial reaches the ocular, and the row behind these two plates consists of four scales to the frontal. Inferior labials

three. Symphyseal is broadly truncate behind. The postsymphyseal (geneial) is a longitudinal oval, and each side is equally divided between the first and second labial and the postgeneial. The latter is separated from the second and third labials by a triangular scute. Preanal pores four; preanal scuta eight, the median much longer fore and aft. Annuli, 196 on the body, and 18 on the tail. The latter is compressed at the extremity so that the tip is a vertical oval. The last half dozen grooves are deep and the scales are represented by semi-globular bosses, as in the genus Rhineüra.

Total length, M. .315; of head to canthus oris, .0095; of tail, .030.

Color above, lead color, with a mulberry shade; below, light yellowish.

APORARCHUS PRUNICOLOR, gen. et. sp. nov.

The genus has been defined in the key under the head of the species *Anops kingii*. It is simply Amphisbæna without preanal pores.

The only specimen on which the species rests is of smaller size than those which represent the species enumerated in the above table, excepting the *A. occidentalis*, which is the smallest of the genus.

Rostral plate scarcely visible from above; common suture of nasals short; nasofrontals each as long as broad; frontals each longer than broad; a pair of well-distinguished square parietals. Labial, 3–3, the third reaching the ocular, so that there is no subocular. No superciliary or preorbital plate. Three plates in the row from canthus oris to frontal plate. Symphyseal broader than long, truncate posteriorly; postsymphyseal broad as long, subcircular, each half bounded by the postgeneial, and first and second labials to an extent represented by the order of mention. Last inferior labial twice as long as deep. Annuli 186 on the body and 23 on the tail. Preanal scales eight, the row preceded by a groove which is wider than the others. Tail obtuse, caudal annuli entirely smooth.

Total length, M. .214; of head to canthus oris, .006; of tail, .029.

Color, uniform plum-color above and below, excepting the lower jaw, chin and part of pectoral region and a postanal crescent, which are white. All the grooves of the inferior surface are white also, so that the animal has a latticed appearance below.

PANTODACTYLUS BIVITTATUS Cope. Proceeds. Academy Philada., 1863, p. 103.

ACRANTUS VIRIDIS Merr. Numerous specimens.

TEJUS TEQUEXIN Linn.

OPHEODES STRIATUS Wagler.

PHALOTRIS MELANOPLEURUS, sp. nov.

The genus *Elapomorphus* of Wiegmann, as defined by Duméril and Bibron, was divided by me in 1863 into three genera, one of which retained the original name, and the other two received the names of Phalotris and Apostolepis. Numerous species have been since added to

the genus, and the new species falling readily into the division I proposed, confirm its propriety. Those with two internasal and two prefrontal plates are true Elapomorphi. They are *E. blumii* Wiegm., *E. wuchereri* Gthr., *E. lepidus* Rhdt., and *E. mexicanus* Gthr. The genus Apostolepis has distinct prefrontal plates but no internasals. The species are: *A. d'orbignyi* D. & B.; *A. flavotorquatus* D. & B.; *A. erythronotus* Peters; and *A. assimilis* Rhdt. In Phalotris there are two internasals, but only one prefrontal. The species are: *P. tricolor* D. & B.; *P. bilineatus* D. & B.; *P. lemniscatus* D. & B., and the subject of the present description.

Scales in different longitudinal rows, all rather short and wide. Muzzle narrow; rostral plate prominent, forming more than a semidisk in outline. Internasals quite small, nearly triangular. Prefrontal wider than long, not reaching labials. Frontal large, its parietal border as long as its superciliary. Parietals elongate; their median suture considerably exceeding length of frontal plate. Nasal elongate behind nostril, touching the preocular, which is longer than high; two small postoculars. Temporals 1–1, the anterior very narrow in one specimen; just reaching, and in another not reaching, inferior postocular. Superior labials six, second and third in orbit. Inferior labials seven, fourth and fifth very large; first in contact with its mate of the other side. Genelals well developed, posterior pair equal to anterior. Gastrosteges, 211; anal double; urosteges, 25. Tail acute.

Color black everywhere, except a wide red dorsal band covering five and two half rows of scales. In one specimen this band is divided on the median row of scales by a black line; in another specimen this line extends but a short way behind the nape. A yellow collar with a black posterior edge above. Sides of throat yellow; head black. The free edges of all the scuta, scutella and black scales, are white.

Total length, M. .311; of head to canthus oris, .006; of tail, .025.

OPHEOMORPHUS DORSALIS Peters. Monatsberichte Berlin Akademie, 1863, p. 283. Abundant.

OPHEOMORPHUS FUSCUS, sp. nov.

Scales in seventeen rows, all but those of five median rows as wide as, or wider than, long. Muzzle moderately obtuse, internasals and prefrontal subquadrate; frontal and superciliary plates elongate; parietals moderate, bifurcate posteriorly. Frontal narrowing posteriorly; posterior angle less than right. Loreal higher than long. Preocular not reaching frontal; two postoculars, both in contact with the single temporal of the first row. Other temporals two, the superior long, leaving but two small ones for contact with the parietals behind, one of them being median. Eight superior labials, fourth and fifth entering orbit; sixth and seventh higher than long. Inferior labials ten, sixth the largest and the last one in contact with the genelals. Postgenelal equal pregenelals. Gastrosteges, 183; anal divided; urosteges, 55.

Above olive or yellowish-brown, all the scales with a blackish border,

which is widest on the apex of the scale. Head above and on sides uniform brown, scuta in some specimens narrowly black-edged. Below yellow, the scuta and scutella with narrow blackish edges, frequently imperfect on the middle of the former.

Total length of a median specimen, M. .695; of head to canthus oris, .019; of tail, .112.

This species is quite abundant at Sao Joao, and some of the specimens reach a larger size than the one measured. It is nearly allied to the *O. meleagris* Shaw, which is, to judge from the collection made, the most abundant snake at Sao Joao. The latter always has nineteen rows of narrow scales, and the color is constantly different. The *O. fuscus* never has the black band through the eye, nor the broad black borders and centres of the cephalic scuta, nor the ventral black spots and cross-bands of the *O. meleagris*. It never has the imperfect black dorsal spots and tail-bands characteristic of the variety *O. m. semilineatus*, which is the most abundant form at Sao Joao. Young specimens of the *O. fuscus* agree exactly with the adult in color.

OPHEOMORPHUS MELEAGRIS Shaw. *Liophis merremii* Dum. Bibron.

Principally represented by the Southern variety, *semilineatus* Cope (Proceedings Academy, Philadelphia, 1860, p. 252). Very abundant. The young of this form have the dorsal spots very distinct, which are feebly represented in the adult. They run more or less together to form imperfect cross-bands, but mostly alternate on opposite sides of the middle line. The top of the head is black.

With increasing age, then, this species becomes much lighter colored; yellowish and light bluish, taking the place of a great deal of black.

APOROPHIS CONIROSTRIS Günther.

APOROPHIS CYANOPLEURUS, sp. nov.

The species of Aporophis (Cope, Proceeds. Amer. Philos. Soc. 1877, p. 18, *Lygophis olim*, nec. Fitzingeri = *Philodryas*) are sometimes referred to Dromicus and sometimes to Liophis. They may be readily distinguished from the latter genus by the absence of scale-fossæ (sometimes called scale pores), while they differ from Dromicus in the shorter tail. This portion represents a fourth or a little more of the total length in Aporophis, and a third or more in Dromicus It is quite possible that the groups may have to be united in one genus in future, but I have not yet met with intermediate forms. The species of Aporophis known to me are: *A. conirostris* Gthr.; *A. lineatus* Linn.; *A. dilepis* Cope*; *A. flavifrenatus* Cope (= *Coronella pulchella* Jan.); *A. anomalus* Gthr. (= *L. rutilus* Cope); *A. nicagus* Cope; *A. undulatus* Wied. (Dromicus Peters); *A. juliæ* Cope; *A. melanocephalus* Peters (*Dromicus melanocephalus*, Monatsber. Berl. Acad., 1863, 277; dentition not described). Aporophis

* This species differs from *A. lineatus* in color, and not only in its two preocular plates, as supposed by Dr. Fischer.

only differs from Rhadinæa in its diacranterian dentition; a character which will probably prove to be not entirely constant.

The present species is quite nearly allied to the *A. undulatus* of Wied. The scales are in seventeen rows, and those of the first row are longer than deep. The rostral plate is transverse, and its apex visible from above. The internasal and prefrontal pair are wider than long. The frontal is elongate and with parallel sides, and its length exceeds that of the muzzle in front of it, and equals that of the common occipital suture. The occipital plates are long, equaling the width between the posterior exterior angles of the superciliary plates. The loreal plate is higher than long. The single preocular reaches the summit of the front, but not the frontal plate. Two postoculars, each deeper than wide. Temporals 1–2–3. Superior labials eight, eye resting on fourth and fifth; all longer than high, excepting the fifth. Inferior labials eight, fifth largest and in contact with postgenecials; all longer than deep. Postgenecials considerably longer than pregenecials. Total length, .805; length of head to rictus oris, .021; length of tail, .245. Gastrosteges, 150; urosteges, 88; anal divided.

Color above bluish olive, with a median dorsal brown band with ill-defined borders, of four scales in width. Sides, up to the front row of scales inclusive, dark slate blue, which forms a band from the canthus oris to the end of the tail, which extends also on the ends of the gastrosteges and urosteges. On the anterior third of the length in the larger specimen, and on the greater part of the body in the smaller, this part of the band isolates itself into dark round spots; on the upper edge of the lateral band every other scale has a pale spot in the centre. Head dark brown above. A black band passes through each eye from the end of the muzzle, and following the edge of the occipitals unites on the nape into a single median band which continues as the dorsal band. Belly yellow, gastrosteges bluish at the bases and edges, forming cross-lines.

TACHYMENIS HYPOCONIA Cope. Proceeds. Academy Phila., 1860, p. 247. *Mesotes obtrusus* Jan., Archiv. p. la Zoologia Modena, 1863, Coronellidæ, p. 96. Abundant.

THAMNODYNASTES NATTERERI Mikan. Abundant.

DRYMOBIUS PANTHERINUS Merrem.

HERPETODRYAS CARINATUS Linn.

PHILODRYAS SCHOTTII Fitz. Abundant.

PHILODRYAS OLFERSII Licht. Abundant.

TROPIDODRYAS ÆSTIVUS D. &. B. *Dryophylax* D. & B.; *Philodryas* Günther.

The name Tropidodryas is proposed for a genus which differs from Philodryas only in having keeled scales. It includes the *T. æstivus* and the *T. serra* (*Dryophylax* D. & B.).

LEPTOGNATHUS CATESBYI D. & B.

OXYRRHOPUS RHOMBIFER D. & B.

OXYRRHOPUS PLUMBEUS Wied.

LYSTROPHIS DORBIGNYI Dum. & Bibr. *Heterodon dorbignyi* Dum. & Bibr.

The generic name Lystrophis is now proposed for the Heterodontes of Duméril and Bibron, which have smooth scales and a divided anal plate. Catachlein has been already proposed by Jan. for the smooth species with entire anal plate.

XENODON RHABDOCEPHALUS Boie.

XENODON NEOVIDII Günth.

HELICOPS INFRATÆNIATUS Jan. Iconographie Ophidiens, Livr. 28, 1868. Pl. iii, fig. 3. *Helicops trivittatus* Cope. Proceeds. Am. Philos. Soc., 1877, p. 92.

One side of the head of the single specimen displays but seven superior labials; the other side eight. Both sides display two loreal plates, one above the other.

HELICOPS BALIOGASTER, sp. nov.

Scales in nineteen longitudinal rows; those of six rows on each side as wide as, or wider than long: all keeled except those of the first row on each side, the second very weakly. Dorsal scales finely striate. Head little distinct, muzzle very short. Nostrils superior. Each nasal plate and the loreal higher than long. Preocular very narrow; two postoculars, each longer than deep. Internasal small; prefrontals wider than long. Frontal long with parallel sides, occipital rather long. Temporals 2—2, the superior of the anterior pair only reaching the postoculars, and in contact with both of them. Superior labials eight, the fourth only entering the orbit. Inferior labials eleven, seventh largest, and the last one in contact with the postgenecials, which are about as long as the pregenecials. Total length, M. .587; of mouth to canthus, .017; of tail, .114. Gastrosteges, 128; one divided anal; scutella, 69.

Superior and lateral surfaces to the middle of the second row of scales blackish brown, with a lighter brown band on the sixth and adjacent halves of the fifth and seventh rows. A yellow lateral band on the adjacent halves of the first and second rows of scales. Belly black with one or two square yellow spots on the middle portions of most of the gastrosteges, which are sometimes so arranged as to leave a black spot in the middle, which together form parts of a median black band on the thoracic region. Tail with a median black band below. A dark cross-band connecting the corners of the mouth across the throat. In a young specimen this cross-band connects the ends of two longitudinal black stripes, which extend from each penultimate inferior labial. A black band on each side of the genecials connected by a cross-bar across the ends of the postgenecials. In the younger specimen the dark brown of the back is lighter, and each

dorsolateral brown band has a row of small dusky spots along its superior and inferior edges.

This species is near the *H. infratæniatus* Jan., and future investigation may prove it to be a variety of that species. In two specimens of the latter the scales are in seventeen rows, in three specimens of the *H. baliogaster* they are in nineteen rows. In a small *H. infratæniatus* the external edges of the dorsal band are not spotted but form a dark band. The color of the lower surface in the two species is quite different.

I note here that the *Helicops alleni* Garman, from Florida, has the scales entirely smooth. It is necessary therefore that it be placed in another genus, which I call Liodytes. Its diagnosis is that of Helicops with the addition, scales smooth.

ELAPS ALTIROSTRIS Cope. Three specimens.

BOTHROPS ALTERNATUS D. & B. Common.

Explanation of Plate.

Heads and tails of Amphisbænidæ. Fig. *a* Head, from above; *b*, from below; *c*, from the side; *d*, the tail with preanal plates and pores, from below.

Fig. 1. *Amphisbæna trachura* Cope.
Fig. 2. *Amphisbæna beniensis* Cope.
Fig. 3. *Amphisbæna occidentalis* Cope.
Fig. 4. *Amphisbæna angustifrons* Cope.
Fig. 5. *Aporarchus prunicolor* Cope.
Fig. 6. *Amphisbæna alba* Linn (Three specimens).
Fig. 7. *A. alba* var. *radiata* Cope. Caudal annuli 18; of the body 236; preanal plates 12; pores 8. Uniform white. Habitat unknown. One specimen.
Fig. 8. *A. alba* var. *dissecta* Cope. Annuli to vent 226; of tail 18; preanal plates 12; pores 8. Brownish above, below white. Venezuela. One specimen.

The Lineal Measures of the Semi-Civilized Nations of Mexico and Central America. By Daniel G. Brinton, M.D.

(*Read before the American Philosophical Society, January 2, 1885.*)

Positive progress in constructive art can be accurately estimated by the kind and perfection of the instruments of precision employed by the artists. A correct theory of architecture or of sculpture must have as its foundation a correct system of weights and measures, and recognized units and standards of gravity and extension. Where these are not found, all is guesswork, and a more or less hap-hazard rule-of-thumb.

In a study of the art-products of Mexico and Central America, it has occurred to me that we may with advantage call linguistics to our aid, and attempt to ascertain, by our analysis of the words for weights and measures, what units, if any, were employed by those who constructed the massive works in that region, which still remain for our astonishment. The tongues I shall examine are the Maya of Yucatan, its related dialect, the Cakchiquel of Guatemala, and the Nahuatl or Aztec of Mexico. The most striking monuments of art in North America are found in the territories where these were spoken at the time of the conquest. The Cakchiquel may be considered to include the Quiche and the Tzutuhil, both of which are closely associated to it as dialects of the same mother tongue.

The Mayas.

The generic word in Maya for both measuring and weighing, and for measures and weights, is at present *ppiz*, the radical sense of which is "to put in order," "to arrange in definite limits." Its apparent similarity to the Spanish *pesar*, French *peser*, etc., seems accidental, as it is in Maya the root of various words meaning battle, to fight, etc., from the "order of battle" observed on such occasions. Any weight or measure is spoken of as *ppizib*, to measure land is *ppiz luum*, a foot measure *ppiz-oc*, etc. But I am quite certain that the original scope of the word did not include weight, as there is no evidence that the ancient Mayas knew anything about a system of estimating quantity by gravity. If the word is not from the Spanish *pesar*, it has extended its meaning since the conquest.

The Maya measures are derived directly, and almost exclusively from the human body, and largely from the hand and foot.

Oc, the foot; *chekoc*, the footstep, the joint or length of the foot as a measure of length. Other forms of the same are *chekel*, *chekeb*, *chekeb-oc*, *chek-oc*, and this abundance of synonyms would seem to show that the measure of a foot was very familiar and frequent. The verb is *chekoc* (*tah*, *té*), as in the phrase:

Chekoctè y otoch Ku.
He measured by feet His house God.

i. e. He measured by feet the church. From this was distinguished—

Xakab, paces or strides, a word confined to the paces of man. The verb is *xakab* (*tah*, *té*), to step off, to measure by paces.

Quite a series of measures were recognized from the ground (or, as some say, from the point of the foot) to the upper portions of the body.

Hun cal coy u-xul (one to the neck of the ankle its-end), extending from the ground to the narrowest portion of the ankle.

Hun pploc u-xul (one calf-of-the-leg its-end), from the ground to the highest portion of the calf of the leg. The word *xul* means end or limit, and is used often adverbially, as in the phrase *uay u-xul*, literally "here its end," or "thus far," (Span. *hasta aqui*).

Hun pixib, the distance from the ground (or point of the toes) to the knee-cap. From *piix*, the knee. Also called *hun hol piix*, from *hol*, head, the knee-cap being called "the knee-head."

Hun hachabex, one girdle, from the ground to the belt or girdle to which the skirt was fastened (from *hach*, to tie, to fasten). The same measure was called *hun theth*, the word *theth* being applied to the knot of the girdle.

Hun tanam, from the ground to the border of the true ribs, from *tanam*, the liver. The *Diccinario de Motul* gives the example, *hun tanam in ual*, one *tanam* (is) my corn, *i. e.*, my corn reaches to my chest. It adds that the measure is from the point of the foot to the chest.

Hun tzem, a measure from the ground to a line drawn from one mamma to the other.

Hun cal u-xul, one neck its-end, from the ground to the border (upper or lower?) of the neck.

Hun chi, from the mouth, *chi*, to the ground.

Hun holom, one head, from the top of the head to the ground. This is also called *hun uallah*, one time the stature or height of a man, from a root meaning "to draw to a point," "to finish off." The Spanish writers say that one *uallah* was equal to about three *varas*, and was used as a square measure in meting corn fields (*Dicc. Motul*). The Spanish *vara* differed as much as the English ell, and to the writer in question could not have represented quite two feet. Elsewhere he defines the *vara* as half a *braza* or fathom. (See below, *betan*.)

The hand in Maya is expressed by the word *kab*, which also means the arm, and is more correctly therefore translated

by the anatomical term "upper extremity." This is not an uncommon example in American tongues. When it is necessary to define the hand specifically the Mayas say *u cheel kab*, "the branch of the arm," and for the fingers *u nii kab*, "the points (literally, noses) of the arm" or upper extremity.

The shortest measurements known to them appear to have been finger-breadths, which are expressed by this phrase *u nii kab*. The thumb was called *u nā kab*, literally "the mother of the hand" or arm, and as a measure of length the distance from the first joint to the end of the nail was in use and designated by the same term.

With the hand open and the fingers extended, there were three different measures or spans recognized by the Mayas.

1. The *nāb*, from the tip of the thumb to the tip of the middle finger.

2. The *ɔeɔnab*, or little *nāb*, from the tip of the thumb to the tip of the index finger. This is the span yet most in use by the native inhabitants of Yucatan (Dr. Berendt).

3. The *chi nāb*, or the *nāb* which extends to the edge, from the tip of the thumb to the tip of the little finger (Pio Perez).

The *kok* was a hand measure formed by closing the fingers and extending the thumb. Measuring from the outer border of the hand to the end of the thumb, it would be about seven inches.

The *cuc* or *noch cuc* (*noch*, is a term applied to a bony prominence, in this instance to the olecranon) was the cubit, and was measured from the summit of the olecranon to the end of the fingers, about eighteen inches.

The most important of the longer measures was the *zap* or *zapal*. It was the distance between the extremities of the extended arms, and is usually put down at a fathom or six feet.

The half of it was called *betan* or *pātan*, meaning "to the middle of the chest." Canes and cords were cut of the fixed length of the *zap* and bore the name *zapalche*, *zap*-sticks, as our *yard-stick* (*che* = stick), and *hilppiz*, measuring rods (*hil*, a species of cane, and *ppiz*, to measure, *Dicc. Motul*).

On this as a unit, the customary land measure was based. It was the *kaan*, one shorter, *hun kaan tah ox zapalche*, a *kaan* of three *zap*, and one longer, *hun kaan tah can zapalche*, a *kaan* of four *zap*. The former is stated to be thirty-six fathoms

square, the latter forty-eight fathoms square. Twenty *kaan* made a *vinic*, man, that amount of land being considered the area requisite to support one family in maize.

The uncertainty about this measure is increased by the evident error of Bishop Landa, or more probably his copyist, in making the *vinic* equal to 400 square feet, which even in the most favored soils would never support a family. He probably said "400 feet square," which in that climate would be sufficient. The *kaan* is said by Spanish writers to be equal to the Mexican *mecate*, which contains 5184 square feet. I acknowledge, however, that I have not reconciled all the statements reported by authors about these land measures.

Greater measures of length are rarely mentioned. Journeys were measured by *lub*, which the Spaniards translated "leagues," but by derivation it means "resting places," and I have not ascertained that it had a fixed length.

The Mayas were given to the drawing of maps, and the towns had the boundaries of their common lands laid out in definite lines. I have manuscripts, some dating as early as 1542, which describe these town lands. In most of them only the courses are given, but not the distances. In one, a title to a domain in Acanceh, there are distances given, but in a measure quite unknown to me, *sicina*, preceded by the numeral and its termination indicating measures, *hulucppiz sicina*, eleven sicinas.*

The maps indicate relative position only, and were evidently not designed by a scale, or laid off in proportion to distance. The distinguished Yucatecan antiquary, the Rev. Don Crescencio Carrillo, in his essay on the cartography of the ancient Mayas,† apparently came to the same conclusion, as he does not mention any method of measurement.

I do not know of any measurements undertaken in Yucatan to ascertain the metrical standard employed by the ancient architects. It is true that Dr. Augustus LePlongeon asserts positively that they knew and used *the metric system*, and that the metre and its divisions are the only dimensions that can be applied

* Acanceh Cheltun. Titulo de un solar y Monte en Acanceh, 1767, MS.

† *Geografia Maya.* Anales del Museo Nacional de Mexico, Tomo II, p. 435.

to the remains of the edifices.* But apart from the eccentricity of this statement, I do not see from Dr. LePlongeon's own measurements that the metre is in any sense a common divisor for them.

From the linguistic evidence, I incline to believe that the *oc*, the foot, was their chief lineal unit. This name was also applied to the seventh day of the series of twenty which made up the Maya month; and there may be some connection between these facts and the frequent recurrence of the number seven in the details of their edifices.†

The Cakchiquels.

The root-word for measuring length is, in Cakchiquel, *et*. Its primitive meaning is, a sign, a mark, a characteristic. From this root are derived the verbal *etah*, to measure length, to lay out a plan, to define limits; *etal*, a sign, mark, limit; *etabal*, measured field; *etamah*, to know, *i. e.*, to recognize the signs and characters of things; *etamanïzah*, to cause to know, to teach, to instruct; etc.

My authorities do not furnish evidence that the Cakchiquels used the foot as a unit of measurement, differing in this from the Mayas. They had, however, like the latter, a series of measurements from the ground to certain points of the body, and they used a special terminal particle, *bem* (probably from *be*, to go), "up to" to indicate such measurements, as *vexibem*, up to the girdle (*vex*, girdle, *i*, connective, *bem*, up to, or "it goes to").

These body measures, as far as I have found them named, are as follows:

quequebem, from the ground to the knee.

ru-vach a, from the ground to the middle of the thigh; literally "its front, the thigh" (*ru*, its, *vach*, face, front, *a*, the muscles of the thigh).

vexibem, from the ground to the girdle, *vex*, which in ancient times supported the breech-cloth.

*"The metre is the *only measure of dimension* which agrees with that adopted by these most ancient artists and architects."—Dr. Le Plongeon, *Mayapan and Maya Inscriptions*, in Proceedings of the American Antiquarian Society, April, 1881.

†"Nearly all the monuments of Yucatan bear evidence that the Mayas had a predilection for the number *seven*," etc. Le Plongeon, *Vestiges of the Mayas*, p. 63, (New York, 1881). Of course, this may have other symbolic meanings also.

qualqaxibem, from the ground to the first true ribs.

kulim, from the ground to the neck (*kul*).

The more exact Cakchiquel measures were derived from the upper extremity. The smallest was the finger breadth, and was spoken of as one, two, three, four fingers, *hun ca*, *cay ca*, *ox ca*, *cah ca* (*ca* = finger). This was used in connection with the measure called *tuvic*, the same that I have described as the Maya *kok*, obtained by closing the hand and extending the thumb. They combined these in such expressions as *ca tuvic rugin hun ca*, two *tuvics* with (plus) one finger breadth (Coto, *Diccionario*, MS.).

The span of the Cakchiquels was solely that obtained by extending the thumb and fingers and including the space between the extremities of the thumb and *middle* finger. It was called *qutu*, from the radical *qut*, which means to show, to make manifest, and is hence akin in meaning to the root *et*, mentioned above.

The cubit, *chumay*, was measured from the point of the elbow to the extremities of the fingers. We are expressly informed by Father Coto that this was a customary building measure. "When they build their houses they use this cubit to measure the length of the logs. They also measure ropes in the same manner, and say, *Tin chumaih retaxic rigam*, I lay out in cubits the rope with which I am to measure." (*Diccionario*, MS.)

The different measures drawn from the arms were:

chumay, from the elbow to the end of the fingers of the same hand.

hahmehl, from the elbow to the ends of the fingers of the opposite hand, the arms being outstretched.

telen, from the point of the shoulder of one side to the ends of the fingers of the outstretched arm on the other side.

tzam telen, from the point of the shoulder to the ends of the fingers of the same side. *Tzam* means nose, point, beak, etc.

ru vach qux, from the middle of the breast to the end of the outstretched hand.

hah, from the tips of the fingers of one hand to those of the other, the arms outstretched.

Another measure was from the point of the shoulder to the wrist.

The *hah*, or fathom, was one of the units of land measure, and the corn fields and cacao plantations were surveyed and laid out with ropes, *gam*, marked off in fathoms. The fields are described as of five ropes, ten ropes, etc., but I have not found how many fathoms each rope contained.

Another unit of land measure in frequent use was the *makoh*. This was the circumference of the human figure. A man stood erect, his feet together, and both arms extended. The end of a rope was placed under his feet and its slack passed over one hand, then on top of his head, then over the other hand, and finally brought to touch the beginning. This gives somewhat less than three times the height. This singular unit is described by both Varea and Coto as in common use by the natives.

There were no accurate measures of long distances. As among the Mayas, journeys were counted by resting places, called in Cakchiquel *uxlanibal*, literally "breathing places," from *uxla*, the breath, itself a derivative of the radical *ux*, to exist, to be, to live, the breath being taken as the most evident sign of life.

There was orignally no word in Cakchiquel meaning "to weigh," as in a balance, and therefore they adopted the Spanish *peso*, as *tin pesoih*, I weigh. Nor, although they constructed stone walls of considerable height, did they have any knowledge of the plumb line or plummet. The name they gave it even shows that they had no idea what its use was, as they called it "the piece of metal for fastening together," supposing it to be an aid in cementing the stone work, rather than in adjusting its lines (Coto, s. v. *Ploma de albañil*).

The Aztecs.

In turning to the Mexicans or Aztecs, some interesting problems present themselves. As far as I can judge by the Nahuatl language, measures drawn from the upper extremity were of secondary importance, and were not the bases of their metrical standards, and, as I shall show, this is borne out by a series of proofs from other directions.

The fingers, *mapilli*, appear to have been customary measures. They are mentioned in the early writers as one equal to an inch. The name *mapilli*, is a synthesis of *maitl*, hand, and *pilli*, child, offspring, addition, etc.

PROC. AMER. PHILOS. SOC. XXII. 118. Z. PRINTED MARCH 14, 1885.

The span was called *miztetl* or *miztitl*, a word of obvious derivation, meaning "between the finger nails," from *iztetl*, finger nail. This span, however, was not like ours, from the extremity of the thumb to the extremity of the little finger, nor yet like that of the Cakchiquels, from the extremity of the thumb to that of the middle finger, but like that now in use among the Mayas (see above), from the extremity of the thumb to that of the index finger ("cuanto se mide con el pulgar y el indice." Molina, *Vocabulario*).

There were four measures from the point of the elbow; one to the wrist of the same arm, a second to the wrist of the opposite arm, a third to the ends of the fingers of the same arm, and the fourth to the ends of the fingers of the opposite arm, the arms always considered as extended at right angles to the body. The terms for these are given somewhat confusedly in my authorities, but I believe the following are correct:

1. From the elbow to the wrist of the same arm; *cemmatzotzopatzli*, "a little arm measure," from *ce*, a, one, *ma* from *maitl*, arm or hand, *tzotzoca*, small, inferior, *patzoa*, to make small, to diminish.

2. From the elbow to the wrist of the opposite arm, *cemmitl*, an arrow, a shaft, from *ce*, and *mitl*, arrow, this distance being the approved length of an arrow. We may compare the old English expression, a "cloth-yard shaft."

3. From the elbow to the ends of the fingers of the same arm, *cemmolicpitl*, one elbow, *ce*, one, *molicpitl* elbow. This is the cubit.

4. From the elbow to the ends of the fingers of the opposite arm.

The following were the arm measures:

cemacolli, from the tip of the shoulder to the end of the hand (*ce*, one, *maçoa*, to extend the arm).

cemmatl, from the tip of the fingers of one hand to those of the other. Although this word is apparently a synthesis of *ce*, one, *maitl*, arm, and means "one arm," it is uniformly rendered by the early writers *una braza*, a fathom.

cenyollotli, from the middle of the breast to the end of the fingers (*ce*, one, *yollotl*, breast).

It is known thut the Aztecs had a standard measure of length

which they employed in laying out grounds and constructing buildings. It was called the *octacatl*, but neither the derivation of this word, nor the exact length of the measure it represented has been positively ascertained. The first syllable, *oc*, it will be noticed, is the same as the Maya word for foot, and in Nahuatl *xocpalli* is "the sole of the foot." This was used as a measure by the decimal system, and there were in Nahuatl two separate and apparently original words to express a measure of ten foot lengths. One was:

matlaxocpallatamachiualoni, which formidable synthesis is analyzed as follows: *matla*, from *matlactli* ten, *xocpal*, from *xocpalli*, foot-soles, *tamachuia*, to measure (from *machiotl*, a sign, or mark, like the Cakchiquel *etal*), *l*, for *lo*, sign of the passive, *oni*, a verbal termination "equivalent to the Latin *bilis* or *dus*" (Carochi, *Arte de la Lengua Mexicana*, p. 123). Thus the word means that which is measurable by ten foot-lengths.

The second word was *matlacyxitlatamachiualoni*.

The composition of this is similar to the former, except that in the place of the perhaps foreign root *xoc*, foot, *yxitl*, foot, is used, which seems to have been the proper Nahuatl term.

As these words prove that the foot-length was one of the standards of the Aztecs, it remains to be seen whether they enlighten us as to the *octacatl*. I quote in connection an interesting passage by the native historian, Fernando de Alva Ixtlilxochitl in his *Historia Chichimeca*, published in Lord Kingsborough's great work on Mexico (Vol. ix, p. 242). Ixtlilxochitl is describing the vast communal dwelling built by the Tezcucan chieftain Nezahualcoyotl, capable of accomodating over two thousand persons. He writes: "These houses were in length from east to west four hundred and eleven and a half [native] measures, which reduced to our [Spanish] measures make twelve hundred and thirty-four and a half yards (*varas*), and in breadth from north to south three hundred and twenty-six measures, which are nine hundred and seventy-eight yards."

This passage has been analyzed by the learned antiquary Señor Orozco y Berra.* The native measure referred to by Ixtlilxochitl was that of Tezcuco, which was identical with that

*Orozco y Berra, *Historia Antigua y de la Conquista de Mexico*, Tomo i, pp. 557-8 (Mexico, 1880).

of Mexico. The yard was the *vara de Burgos*, which had been ordered to be adopted throughout the colony by an ordinance of the viceroy Antonio de Mendoza. This vara was in length 0.838 metre, and as according to the chronicler the native measure was just three times this ($411\frac{1}{2} \times 3 = 1234\frac{1}{2}$, and $326 \times 3 = 978$), it must have been 2.514 metre. This is equal in our measure to 9.842 feet, or, say, nine feet ten inches.

This would make the *octacatl* identical with those long-named ten-foot measures, which, as I have shown, were multiples of the length of the foot, as is proved by an analysis of their component words.

This result is as interesting as it is new, as it demonstrates that the metrical unit of ancient Mexico was the same as that of ancient Rome—the length of the foot-print.

Some testimony of another kind may be brought to illustrate this point.

In 1864, the Mexican government appointed a commission to survey the celebrated ruins of Teotihuacan, under the care of Don Ramon Almaraz. At the suggestion of Señor Orozco this able engineer ran a number of lines of construction to determine what had been the metrical standard of the builders. His decision was that it was "about" met. 0.8, or, say, $31\frac{1}{2}$ inches.* This is very close to an even third of the *octacatl*, and would thus be a common division of lengths laid off by it.

I may here turn aside from my immediate topic to compare these metrical standards with that of the Mound-Builders of the Ohio valley.

In the *American Antiquarian*, April, 1881, Prof. W. J. McGee applied Mr. Petrie's arithmetical system of "inductive metrology" to a large number of measurements of mounds and earth-works in Iowa, with the result of ascertaining a common standard of 25.716 inches.

In 1883, Col. Charles Whittlesey, of Cleveland, analyzed eighty-seven measurements of Ohio earth-works by the method of even divisors and concluded that thirty inches was about the

* *Memoria de los Trabajos ejecutados por la comision scientifica de Pachuca en el año de 1864*, p. 357, quoted by Orozco. Almaraz's words are not at all precise: "la unidad lineal, con pequeñas modificaciones, debió ser cosa de 0, m 8, ó cuatro palmos próximamente."

length, or was one of the multiples, of their metrical standard.*

Moreover, fifty-seven per cent of all the lines were divisible without remainder by ten feet. How much of this may have been owing to the tendency of hurried measurers to average on fives and tens, I cannot say, but leaving this out of the question, there is a probability that a ten foot-length rule was used by the "mound-builders" to lay out their works.

It may not be out of place to add a suggestion here as to the applicability of the methods of inductive metrology to American monuments. The proportions given above by Ixtlilxochitl, it will be noted, are strikingly irregular (411½, 326). Was this accident or design? Very likely the latter, based upon some superstitious or astrological motive. It is far from a solitary example. It recurs everywhere in the remarkable ruins of Mitla. "Careful attention," says Mr. Louis H. Aymé, "has been paid to make the whole asymmetrical. * * * This asymmetry of Mitla is not accidental, I am certain, but made designedly. M. Désiré Charnay tells me he has observed the same thing at Palenque." These examples should be a warning against placing implicit reliance on the mathematical procedures for obtaining the lineal standards of these forgotten nations.†

Whatever the lineal standard of the Aztecs may have been, we have ample evidence that it was widely recognized, very exact, and officially defined and protected. In the great market of Mexico, to which thousands flocked from the neighboring country (seventy thousand in a day, says Cortes, but we can cut this down one-half in allowance for the exaggeration of an enthusiast), there were regularly appointed government officers to examine the measures used by the merchants and compare them with the correct standard. Did they fall short, the measures were broken and the merchant severely punished as an enemy to the public weal.‡

* *The Metrical Standard of the Mound-Builders.* Reduced by the Method of Even Divisors. By Col. Chas. Whittlesey (Cleveland, 1883).

† *Notes on Mitla*, in *Proceedings of the American Antiquarian Society*, April, 1882, p. 97.

‡ See Herrera, *Decadas de Indias*, Dec. ii, Lib. vii, cap. xvi, and Dec. iii, Lib. iv, cap. xvii. "Castigaban mucho alque falseaba medidas, diciendo que era enemigo de todos i ladron publico," etc.

The road-measures of the Aztecs was by the stops of the carriers, as we have seen was also the case in Guatemala. In Nahuatl these were called *neceuilli*, resting places, or *netlatolli*, sitting places; and distances were reckoned numerically by these, as one, two, three, etc., resting places. Although this seems a vague and inaccurate method, usage had attached comparatively definite ideas of distance to these terms. Father Duran tells us that along the highways there were posts or stones erected with marks upon them showing how many of these stops there were to the next market-towns—a sort of mile-stones, in fact. As the competition between the various markets was very active, each set up its own posts, giving its distance, and adding a curse on all who did not attend, or were led away by the superior attractions of its rivals!*

So far as I have learned, the lineal measures above mentioned were those applied to estimate superficies. In some of the plans of fields, etc., handed down, the size is marked by the native numerals on one side of the plan, which are understood to indicate the square measure of the included tract. The word in Nahuatl meaning to survey or measure lands is *tlalpoa*, literally "to count land," from *tlalli* land, *poa* to count.

The Aztecs were entirely ignorant of balances, scales or weights. Cortes says distinctly that when he visited the great market of Mexico, Tenochtitlan, he saw all articles sold by number and measure, and nothing by weight.† The historian, Herrera confirms this from other authorities, and adds that when grass or hay was sold, it was estimated by the length of a cord which could be passed around the bundle.‡

The plumb-line must have been unknown to the Mexicans, also. They called it *temetztepilolli*, "the piece of lead which is hung

*Habian terminos señalados de cuantas leguas habian de acudir à los mercados," etc. Diego Duran, *Historia de la Nueva España*, Vol. ii, pp. 215, 216. Both the terms in the text are translated *legua* in Molina's Vocabulary, so that it is probable that the resting places were something near two and a half to three miles apart.

†"Todo lo venden por cuenta y medida, excepto que fasta agora no se ha visto vender cosa alguna por peso." *Cartas y Relaciones de Hernan Cortes*, p. 105. (Ed. Gayangos.)

‡"Tenian medida para todas las cosas; hasta la ierva, que era tanta, quanta se podia atar con una cuerda de una braza por un tomin." Herrera, *Decadas de Indias*, Dec. iii, Lib. vii, cap. xvi. In another passage where this historian speaks of weights (Dec. iii, Lib. iv, cap. xvii), it is one of his not infrequent slips of the pen.

from on high," from *temetztli*, lead, and *piloa*, to fasten something high up. Lead was not unknown to the Aztecs before the conquest. They collected it in the Provinces of Tlachco and Itzmiquilpan, but did not esteem it of much value, and their first knowledge of it as a plummet must have been when they saw it in the hands of the Spaniards. Hence their knowledge of the instrument itself could not have been earlier.

The conclusions to which the above facts tend are as follows:

1. In the Maya system of lineal measures, foot, hand, and body measures were nearly equally prominent, but the foot unit was the customary standard.

2. In the Cakchiquel system hand and body measures were almost exclusively used, and of these, those of the hand prevailed.

3. In the Aztec system, body measurements were unimportant, hand and arm measures held a secondary position, while the foot measure was adopted as the official and obligatory standard both in commerce and architecture.

4. The Aztec terms for their lineal standard being apparently of Maya origin, suggest that their standard was derived from that nation.

5. Neither of the three nations was acquainted with a system of estimation by weight, nor with the use of the plumb-line, nor with an accurate measure of long distances.

An Experiment in Weather Forecast. By Pliny Earle Chase, LL.D.

(*Read before the American Philosophical Society, Jan. 16, 1885.*)

The class of '88, in Haverford College, have studied Chase's Elements of Meteorology, with a special view to the formation of trained habits of observation. They have acquired such skill in local weather forecast* that they undertook, early in December, to predict the probable regions of fair and stormy weather for all parts of the United States, on Christmas and New Year's days. The predictions were forwarded to Washington and submitted, through the courtesy of Gen. W. B. Hazen, Chief Signal

*The verifications, after two months' study, ranged between 74 and 90.3 per cent, the general average being 81.5 per cent.

Officer U. S. A., to the Board of Indications, to ascertain the degree of accuracy.

The following were the grounds of forecast:

1. The mechanical influence of solar and lunar tides on atmospheric currents, which has been tested by sixteen years' investigation and observations at Philadelphia and Haverford College. The normal tendency of tidal pressure, independent of friction, polar and equatorial currents and other disturbing influences, is from the East at syzygy, from the South at the following octant, from the West at quadrature, and from the North at the following octant, thus forming a lunar wind-rose, of a like character to Dove's solar wind-rose.

2. The normal percentage of average lunar rainfall on the several days of the lunar month, as deduced from three years' observations of the Signal Service Sergeants (Proc. Amer. Phil. Soc. xiv, 416–8).

3. The Signal Service tables of the winds which are most likely, as well as of those which are least likely, to be followed by rain or snow in each region, during each month of the year.

I had previously stated (Elements of Meteorology, Part i, p. 95), that "a verification of lunar forecasts in five cases out of nine should be re-"garded as satisfactory. In favorable localities, if due regard is paid to "temporary local influences, predictions may often be made for a month "in advance, which will prove true in three cases out of four." The reports which were received from the Signal Office were examined in several different ways, the lowest mean verification of lunar influence for the two days being 59 per cent., while the highest was 100 per cent., as is shown by the following tests:

I. *Tests of Lunar Influence.*

a. The tri-daily bulletins of the Signal Service Bureau, show that in 13 of the 22 regions, or 59.1 per cent., there were such differences of barometric pressure between the two days of observation as should be produced by tidal influence, viz: increased pressure when the normal currents are retarded, diminished pressure when they are accelerated.

β. The normal relation of temperature to pressure (thermometer rising when barometer falls, and *vice versa*) was shown in 17 of the 22 regions, or 77 per cent.

γ The tendency to partial reversal of surface currents by friction, in passing over the land, and consequent partial opposition of lunar influence,* was shown in 19 of the 22 regions, or 86 per cent.

δ. The rainfall on Christmas day was 1.07 times as great as that upon New Year's day. The lunar normal ratio was 1.04. This represents a verification of 97 per cent.

ϵ. The influence of "favorable localities," independent of any regard to "temporary local influences," was shown in the Middle Atlantic States,

* Elements of Meteorol. Part i, pp. 93-5, Par. 1, 8; Proc. Amer. Phil. Soc., xi, 113.

where the verification was 100 per cent., the weather at every station, on each of the days, being such as was foretold.

II. *Tests of Solar Influence.*

ζ. The special report of the Board of Indications, showed a verification of 70.7 per cent. for the fair forecasts and a rainfall, in amounts sufficient to be measured, in 25 per cent. of the regions for which stormy indications were foretold. The full significance of this test cannot be satisfactorily determined, because the normal proportion of stormy winds which bring actual rainfall has never been published.

η. The forecasts which were authorized by the Signal Service tables showed a verification of $1275 \div 19 = 67.1$ per cent. on Christmas day, and of $575 \div 15 = 38.5$ per cent. on New Year's Day, or a general mean of $1850 \div 34 = 54.4$ per cent. In three of the regions at the former date, and in seven at the latter, no forecasts were prescribed by the tables, the wind-deflecting tendencies being from doubtful azimuths. This test, like the foregoing, is affected by the uncertainty as to what constitutes a satisfactory verification of storm-forecasts which cover winds from one-half of the azimuths.

θ. As nearly as could be ascertained from the tri-daily reports, the stormy indications in the Signal Service tables were verified in 65 per cent. for the fair winds, and there was measurable precipitation after 43 per cent. of the stormy winds, the general mean verification being 60 per cent. This would indicate a verification, according to the preceding test, of $54.4 \div 60 = 90.7$ per cent.

ι. The ratio of lunar to solar monsoon influence, which was shown in tests α and η ($59.1 \div 54.4 = 1.086$) agrees very nearly with the ratio which was shown by the winds at Haverford during the past year ($545 \div 514 = 1.06$). Of 1059 observations, 545 were nearer the azimuth which represented the lunar tidal tendency and 514 nearer that which represented the solar monsoon influence, as given by Coffin (Winds of the Globe, p. 431). This degree of accordance seems to justify the belief that the subsidiary value of lunar normals would be found as great elsewhere as it is at Haverford, for detecting and coördinating the abnormal influences of equatorial or polar, cyclonic or anticyclonic, local or general currents.

III. *Tests at Haverford College for 1884.*

κ. Tidal acceleration of atmospheric currents was accompanied by low barometer; tidal retardation by high barometer.

λ. The percentage, both of stormy winds and of cloudiness, was greater in the lunar stormy cycles than in the fair cycles.

μ. Of the 120 days on which the lunar tidal tendencies were more stormy than fair, 54 were accompanied by measurable precipitation; on 32 other days there were winds from stormy directions; 11 others were

cloudy, and on 23 days no special evidence of stormy disturbance was recorded. This represents 81 per cent. of verification by storm or stormy tendency, and 19 per cent. of failure.

ν. Of the 120 days on which the lunar tidal tendencies were more fair than stormy, 74 were fair; on 21 other days there were winds from fair directions, and on 25 days there was rain or snow with no special record of fair influence. This represents 62 per cent. of complete verification, 17 per cent. of partial verification, and 21 per cent. of failure.

ξ. Making allowance for one day's possible shifting of fair and stormy tendencies, by the acceleration of equatorial cyclonic currents, or the retardation of polar anticyclonic currents, 85 per cent. of the fair, 71 per cent. of the stormy, and 79 per cent. of all the indications were completely verified. In this test no stormy verification was admitted in which there was not an actual measurable amount of rain or snow.

o. Of the winds from stormy quarters during the year, 63 per cent. were followed within 24 hours by measurable amounts of rain or snow. Of the winds from fair quarters, 72 per cent. were followed by fair weather for 24 hours, with no measurable amount of rain or snow. The mean verification of all the wind indications was 68 per cent.

π. The comparative value of forecasts, from lunar indications which might have been foretold years in advance, and from wind indications which are good only for a day in advance, was $45 \div 63 = 71.4$ per cent. for storm; $62 \div 72 = 86.1$ per cent. for fair; $53 \div 68 = 77.9$ per cent. for all.

ρ. The percentage of verification for stormy indications was greatest in winter and least in summer.

σ. The percentage of verification for fair indications was greatest in autumn, and least in winter. There were marked indications, however, of a tendency toward general maximum verification in summer.

τ. The percentage of total verification was greatest in winter, when the thermal disturbance of Moon's tidal action is least, and least in summer, when the thermal disturbance is greatest.

υ. The percentage of verification, both for the fair and for the stormy indications, was greater in the equinoctial semester than in the solstitial.

φ. The conflict of solar daily and monsoon influences with lunar monthly tidal influences was shown in numerous cases of stormy anticyclonism and fair cyclonism which had been overlooked in the daily forecasts from Washington. Predominating solar influence accounted for 32 of the 46 abnormal days during the fair lunar tendencies, and 51 of the 66 abnormal days during the stormy lunar tendencies, or 74 per cent. of the whole.

It would be unwise to draw any positive conclusions from the results of a single experiment, or from observations for a single year at a single station, but there is certainly encouragement for continuing the line of investigation which is here indicated.

Note on Cosalite, Alaskaite and Beegerite. By George A. Koenig.

(Read before the American Philosophical Society, January 16, 1885.)

The discovery of another rich vein of Bismuth silver ore in Ouray Co., Colorado, last spring, has developed new interest in the sulphobismuthite minerals. The new discovery is called "Gladiator," and is situated, according to Mr. Stockder, my correspondent, at the mouth of Poughkeepsie gulch into the Uncompaghre valley. The "Alaska" is situated at the head of this gulch, some six or eight miles above the Gladiator.

My esteemed friend and colleague, Prof. F. A. Genth, examined some specimens of the new find, whilst others awaited my return from Europe.

In connection with this investigation, Dr. Genth also analyzed material from a specimen, which I had given him as "Alaskaite" from the Alaska mine. The results of his analysis did not agree with the composition of alaskaite, as found by me, but rather with cosalite. To make doubly sure, he kindly asked me to repeat the analysis with well selected material from the same specimen. I did so with the following result:

Bi	=	43.54
Pb	=	26.77
Ag	=	1.35
Cu	=	8.78
Fe	=	0.52
Zn	=	trace
Sb	=	undet.
S	=	17.13
Insoluble	=	0.60
		98.69

Particles of chalcopyrite could not be excluded in picking. It we deduct the iron, with a corresponding quantity of copper and sulphur as chalcopyrite, we have

Bi	=	43.54 : 210	=	0.2007
Pb	=	26.77 : 206.4	=	0.1298
Ag	=	1.35 : 215.3	=	0.0065
Cu	=	8.22 : 129.6	=	0.0673
				0.2036
S	=	16.54 : 32	=	0.5169
(Pb, Ag_2, Cu_2) : Bi : S	=	1.01 : 1 : 2.57		

or 2 RS + $Bi_2 S_3$ = Cosalite.

Although I had used the same methods in the analysis of alaskaite, I felt induced to reëxamine my type specimens of that species. Upon closer examination the difference in color between this cosalite and the alaskaite becomes unmistakable. Still I might have been mistaken. The material was picked with much care, more than in my first examination, as will be seen by comparison of the results. It was scarce in conse-

quence, and one-half gram only was used for each analysis. Of one analysis all but the lead determination was lost.

After separating Pb and Bi by dilute sulphuric acid and weighing the first as $PbSO_4$, the latter was dissolved in NaHO, and if a residue remained, it was dissolved in NHO_3 evaporated with dil. H_2SO_4, and thus a complete separation of Bi and Pb effected. Bi was weighed as BiClO.

The spec. gravity of 1.014 gr. was found = 6.782.

The analysis gave :

Bi	=	53.39
Pb	=	12.02 (mean of 11.88 + 12.16)
Ag	=	7.80
Cu	=	5.11
Fe	=	0.84
Zn	=	0.34
S	=	17.98
Sb	=	undet.
Insoluble	=	1.80
		99.16

If we deduct again 0.84 Fe + 0.95 Cu + 0.94 S as chalcopyrite, we have as belonging to the light gray mineral :

Bi	=	53.39 : 210	=		0.2542
Pb	=	12.02 : 206.4	=	0.0582	0.1317
Cu	=	4.16 : 129.6	=	0.0321	
Ag	=	7.80 : 215.3	=	0.0362	
Zn	=	0.34 : 64.9	=	0.0052	
S	=	17.04 : 32	=		0.5330

R : Bi : S = 1 : 1.93 : 4.05

that is (Pb, Cu_2, Ag_2, Zn) S + Bi_2S_3 = Alaskaite.

If the zinc be left out of the molecule, the ratio of 1 : 2 is perfect. It may be presumed therefore that the alaskaite is certainly a valid species, and that it occurs with cosalite at the Alaska mine. From the latter species only the lighter gray color distinguishes it, but one must see the two together to notice the difference. The discovery of the cosalite at this mine we owe to Dr. Genth.

Among the specimens, which I received through Mr. Stockder of Lake City, from the "Old Lout" I noticed a very fine granular lead gray mineral which appears mixed with pyrite, chalcopyrite, barite and quartz. I succeeded in getting 1.11 gr. of it in a very fair degree of purity. Its specific gravity, uncorrected, is 6.565. Its composition as follows :

Bi	=	19.35
Pb	=	45.87
Ag	=	9.98
Cu	=	1.12
Fe	=	2.89
S	=	16.39
Insoluble	=	0.12
		95.72

For the loss of 4.3 per cent in this analysis I can at present not account. Iron and copper eliminate themselves as chalcopyrite and pyrite; remain

Bi	=	19.35 : 210	=	0.0930
Pb	=	45.87 : 206.4	=	0.2216 } 0.2878
Ag	=	9.98 : 215.3	=	0.0462 }
S	=	13.37 : 32	=	0.4180
R : Bi : S	=	3.09 : 1 : 4.5		

that is 6.18 $(PbAg_2)$ S + Bi_2S_3 = Beegerite.

The original beegerite, crystallized, from Clear Creek county, Colorado, contains no silver at all. Apparently this interesting species, only existing in one specimen heretofore, is not rare at the new locality, and may be procurable to collectors.

I reserve a more satisfactory examination to the future.

University of Pennsylvania, Jan., 1884.

The Remarkable Sun-glows in the Falls of 1883 and 1884.

By Wm. Blasius.

(*Read before the American Philosophical Society, January 16, 1885*).

There has been much speculation by scientists as to the true explanation of those extraordinary sun-glows that astonished the world in November of 1883, and reappeared in a somewhat lesser degree at about the same time in 1884. In the attempt to explain the brilliancy of this phenomenon, some few meteorologists started on that philosophical principle, that it differs from the usual sun-rises and sun-sets only in degree, and not in kind, and that an explanation must be found in the same laws that govern the ordinary phenomena, *i. e.*, in the refraction of the sun's rays in the stratum of moist air that surrounds the earth's surface.

These views found their difficulty in the fact that the atmosphere during the time the extraordinary phenomenon took place was comparatively dry, at any rate, that its moisture did not appear to reach to an altitude sufficiently elevated, to cause the glows to extend to that extraordinary height that they appeared to reach.

To overcome this difficulty, some meteorologists brought the mysterious cyclone into play. The cyclone whirls, so they say, the moist air to an elevation sufficiently high to account for the phenomenon. If the position of the cyclone were such as to allow the sun's rays to pass, in its highest region, through only one side of it; the highest portion of the sun-glows might find a satisfactory explanation; but as it would be difficult for the sun's rays to pass through both sides of the cyclone, the lower portion of the sun-glows seems to be left unaccounted for.

When meteorologists failed to satisfactorily solve the problem, the astronomers took the case in hand, and looked for an adequate cause ex-

traneous to the atmosphere. Prof. Young in Genf finds it in cosmic dust; Easterby ascribes the cause to chemical changes in the sun; others ascribe it to the influence of the aurora borealis or to the zodiacal light. Lockyer considered that the volcanic ashes thrown into the air by the eruptions of the Krakatoa, in August, 1883, is the true cause; but I suppose he has changed his views by this time, as the phenomenon reappeared in 1884 without the recurrence of any eruption.

I will not enter into a criticism of these different views, but the general impression is that the phenomenon remains as much a puzzle as ever. This is perhaps not surprising, for so long as meteorologists continue to hold to the old theory, that the movements and changes of the air in the Temperate zone are of a cyclonic nature, so long they will be unable to satisfactorily explain most meteorological phenomena, and the brilliant sun-glows only add another to the list of failures.

Seen from a standpoint I believe I have found by a study of nature to be the true one, meteorological phenomena appear to the observer in a natural undistorted state, and they are easily understood and explained. The sun-glows and the ordinary sunset brilliancies, are caused by the same forces, but under different meteorological conditions, which cannot be understood so readily, when seen from the standpoint of the old cyclonic theory. In the one, as well as in the other case, the color is produced by the refraction of the sun's rays in a stratum or sheet of moist air. The surrounding stratum of moist air is often observed, especially during the time the sun rises and sets; therefore, the phenomena on a small scale take place frequently. The more magnificent phenomenon can only take place when, in the progress of the equatorial air current northward, the warm, moist current comes between the observer and the rising or setting sun. There is then going forward a displacement of the cold, dry polar current or wave, by the moist warm equatorial current or wave, the latter slanting obliquely up and over the polar air. Where these currents meet they lie in the position of two wedges, the polar current having the thin edge of its wedge toward the south, on the surface. The warm, moist equatorial current has the thin end of its wedge or sphenoid up and above the cold current toward the north; its progress is generally indicated by cirrus clouds, which in the further progress, change into cirro-stratus. If the observer is now situated in the polar current, he will find the temperature low, the barometer high, and the air comparatively dry, the wind coming from a northerly direction. Between him and the rising or setting sun he would encounter, if he ascended in a balloon, the equatorial current, a body of moist warm air in the shape of a sphenoid, or wedge, or a prism. If there is a coincidence of the proper conditions, especially if the plane of meeting of the two currents has a tolerably steep inclination, the brilliant phenomenon as described will show itself.

For a more elaborate exposition of the relations of these equatorial and polar currents under such circumstances, I must refer to my work:

"Storms; their nature, classification and laws, with the means of predicting them." (Porter & Coates, publishers.) Especially to Plate vii, p. 76, where will be found diagrams representing the north-east storm in its progress, *i. e.*, the warm moist southern current replacing the cold, dry northern current.

Let us now examine how these views agree with the actual state of the atmosphere on October 26, 1884, when this phenomenon last appeared. To this end I copy the record from the United States Signal Service record:

	7 A. M.	11 A. M.	3 P. M.	7 P. M.	11 P. M.	3 A. M.
Barometer,	30597	30607	30560	30566	30556	30550
Temperature,	33.0	44	48.6	45.4	43.5	34.6
Dew point,	24.0	20	27.0	30.6	30.5	19.6
Humid.,	68	37	46	56	60	53
Dir. of wind,	N.	N.	S.	S.E.	S.E.	N.
Clouds,	0	0	0	Cir. Cum.	0	0
	Clear.	Clear.	Clear.	Cloudy.	Clear.	Clear.

From this we see that the meteorological conditions of the atmosphere coincided favorably to show the phenomena in question to an observer in Philadelphia. High barometer, low temperature, clear weather, northerly wind. At 3 P. M. the wind came from the south, then the temperature rose, the pressure decreased, and toward 7 P. M. Cir. Cum. appeared, indicating that the equatorial warm moist air, flowed obliquely over the polar current, and that it took a position between the observer in Philadelphia and the setting sun, and that the sun's rays of necessity went through the sphenoid or prism of the body of moist warm air, and so produced the brilliancy as described. Prof. Clement Hess,* from Frauenfeld, describes similar conditions in the atmosphere when the phenomenon took place in November 3, 1883, at his place of observation. The day preceding, all Europe was under high pressure, then came cirrus and cirrostratus, with low pressure in their rear traveling eastward. Prof. Hess considers this low pressure a forward moving cyclone. Seen from my standpoint, it is the equatorial current lying in the form of a sphenoid above the polar current. The sun's position in relation to the inclination of the plane of meeting or the gradient, is evidently of much importance, and if we had all the facts, the result would be mathematically determined.

If now it is asked why the brilliant sun-glows should not be observed every autumn, I think the answer is that it but infrequently happens that at this season of the year, when the sun is in position to produce this effect, the equatorial current reaches to sufficiently high altitudes. And, it will be remembered, that both in 1883 and to a less degree in 1884, the approach of winter was exceptionally late, the equatorial current remaining much longer than usual in its summer position.

* Zeitschrift der Ostreichischen Gesellschaft für Meteorologie, xviii Band, p. 20.

A convenient Device to be applied to the Hand Compass.

By Persifor Frazer.

(*Read before the American Philosophical Society, December 5, 1884.*)

In the course of my professional work, it is very often necessary to make rapid reconnaissance surveys where absolute accuracy of detail is not necessary, and where superfluous equipage is to be avoided as much as possible. As a consequence those who have most experience with this kind of rough geological topography, following to the extent of their ability the example of its most distinguished expositor, Prof. J. P. Lesley, rely very largely upon determination of direction by the ordinary hand compass. This has many inconveniences, and is only possible of application by those who have had considerable experience. In the first place, there are no sights to direct the eye, nor any means to prevent the derangement of the needle, between the time that the sight is taken, and that when it is read off. Add to this the liability of the ordinary hand compass to be broken if its glass face be unprotected; or the cover lost, if this be of the ordinary unattached kind.

The difficulty alluded to last, had already been met, by the hunting case pocket compass which has been recently quite widely distributed. As regards the other difficulties, the old prismatic compass is their most satisfactory solution, except that it is more expensive, more liable to get out of order, and more accurate than the necessities of the case frequently require. A hunting case pocket compass with a bright reflecting inner surface of the cover was provided with a slot, one millimeter in width, reaching from the top to the north point of the compass dial. By holding this compass in the ordinary position for taking sight with the open cover at a distance of the diameter of the compass dial from the eye, it will be found that objects can be seen with sufficient distinctness to enable one to centre them easily, and at the same time the position of the needle can be read off by its reflection in the movable cover. This slot also takes the place of the gnomon in the ingenious compass devised by Major T. B. Brooks, some ten years ago, and like that compass may be used to determine the variation of the magnetic needle. In the absence of local attraction, the time of noon being known, the true north can be determined, and hence the magnetic declination of the place. Or the variation being known, the time of day can be determined by suitable marks on the periphery of the disc, or the variation being known, the needle can be used to discover the direction and amount of local magnetic attraction.

him the communication, description, or model, except the officer to whom it shall be entrusted; nor shall such officer part with the same out of his custody, without a special order of the Society for that purpose.

6. The Society, having previously referred the several communications from candidates for the premium, then depending, to the consideration of the twelve counsellors and other officers of the Society, and having received their report thereon, shall, at one of their stated meetings in the month of December, annually, after the expiration of this current year (of the time and place, together with the particular occasion of which meeting due notice shall be previously given, by public advertisement) proceed to final adjudication of the said premium; and, after due consideration had, a vote shall first be taken on this question, viz.: Whether any of the communications then under inspection be worthy of the proposed premium? If this question be determined in the negative, the whole business shall be deferred till another year; but if in the affirmative, the Society shall proceed to determine by ballot, given by the members at large, the discovery, invention or improvement most useful and worthy; and that discovery, invention, or improvement which shall be found to have a majority of concurring votes in its favor shall be successful; and then, and not till then, the sealed letter accompanying the crowned performance shall be opened, and the name of the author announced as the person entitled to the said premium.

7. No member of the Society who is a candidate for the premium then depending, or who hath not previously declared to the Society, that he has considered and weighed, according to the best of his judgment, the comparative merits of the several claims then under consideration, shall sit in judgment, or give his vote in awarding the said premium.

8. A full account of the crowned subject shall be published by the Society, as soon as may be after the adjudication, either in a separate publication, or in the next succeeding volume of their Transactions, or in both.

9. The unsuccessful performances shall remain under consideration, and their authors be considered as candidates for the premium for five years next succeeding the time of their presentment; except such performances as their authors may, in the meantime, think fit to withdraw. And the Society shall annually publish an abstract of the titles, object, or subject matter of the communications, so under consideration; such only excepted as the Society shall think not worthy of public notice.

10. The letters containing the names of authors whose performances shall be rejected, or which shall be found unsuccessful after a trial of five years, shall be burnt before the Society, without breaking the seals.

11. In case there should be a failure, in any year, of any communication worthy of the proposed premium, there will then be two premiums to be awarded the next year. But no accumulation of premiums

shall entitle the author to more than one premium for any one discovery, invention or improvement.

12. The premium shall consist of an oval plate of solid standard gold of the value of ten guineas. On one side thereof shall be neatly engraved a short Latin motto suited to the occasion, together with the words: "The Premium of John Hyacinth de Magellan, of London, established in the year 1786;" and on the other side of the plate shall be engraved these words: "Awarded by the A. P. S. for the discovery of ——— A.D. ———." And the seal of the Society shall be annexed to the medal by a ribbon passing through a small hole at the lower edge thereof.

SECTION 2. The Magellanic fund of two hundred guineas shall be considered as ten hundred and fifty dollars, and shall be invested separately from the other funds belonging to or under the care of the Society, and a separate and distinct account of it shall be kept by the treasurer.

The said fund shall be credited with the sum of one hundred dollars, to represent the two premiums for which the Society is now liable.

The treasurer shall credit the said fund with the interest received on the investment thereof, and, if any surplus of said interest shall remain after providing for the premiums which may then be demandable, said surplus shall be used by the Society for making publication of the terms of the said premium, and for the addition, to the said premium, of such amount as the Society may from time to time think suitable, or for the institution of other premiums.

The treasurer shall, at the first stated meeting of the Society in the month of December annually, make a report of the state of said fund and of the investment thereof.